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THE NEW PHYSICS

SOUND

BY JOSEPH BATTELL

AUTHOR OF THE SCIENTIFIC WORK, "ELLEN OR WHISPERINGS OF AN OLD PINE,"
"THE HOME LIBRARY," "THE MORGAN HORSE AND REGISTER,"
"AMERICAN STALLION REGISTER," ETC., ETC.

"Seek, and ye shall find."

"Truth, crushed to earth, shall rise again;
The eternal years of God are hers."

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TO THE
PEOPLE OF ALL COUNTRIES
THIS BOOK IS DEDICATED
BY THE
AUTHOR

PREFACE.

WE submit the following clear statement in regard to the Undulatory Theory of Sound, from the Article on Acoustics in the London Encyclopædia, a large and able work of 22 volumes, published at London, England, in 1827 (Todd's edition) "by the original editor of the Encyclopædia Metropolitana, assisted by eminent professional and other gentlemen:"

"Strange it is, that upon a topic which has exercised the powers of a Bacon, a Newton, and a Boyle, and to which some of our most accurate modern experimenters have also directed their attention, so little that is satisfactory in theory can be produced. There is, in fact, hardly any *doctrine* of acoustics, that can be offered with confidence to the reader. Embracing phenomena, which must have attracted the attention of mankind from the earliest period of history, and which as it is connected with music, and every modulation of the human voice, offers much that is in the highest degree essential to the pleasure of social intercourse, a philosophical theory of sound seems as yet to have eluded research. We shall, in this article, therefore only attempt a record of the best opinions upon the subject that have been given by our predecessors: fairly avowing to our readers, that we look to a better digest of past experiments, and many future additional ones, for a more satisfactory theory than any that has yet been offered: every one that we have yet seen being in many important points, inconsistent with well recorded facts and observations.

"Philosophers, in attempting to find the immediate cause of sonorous motion, tell us that all bodies consist of an infinite number of invisible parts or corpuscles perfectly hard and incompressible; that these are surrounded by particles differing according to the different union and figures of their component parts; and that these last being compressed by an external power or impulse, have a constant tendency to restore themselves to their settled and former state. It is this motion of the latter particles which M. Perrault and others consider as the proximate cause of sound. So that if we rightly understand this theory, it is simply the struggle of the elastic *portion* of bodies which produces the phenomenon in question. But what proof has ever been offered of the existence of these hard and impressible portions?

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"Various objections have been made to the Newtonian system of sounds. It is urged, that this theory can only agree with the motion of sound in an elastic fluid, whereas sounds are known to move forward through water that is not elastic. To explain their progress therefore through water, a second theory must be formed: so that two theories must be made to explain a similar effect; which is equally contrary to the simplicity of true philosophy, and of nature.

To get rid of this difficulty the scientists have changed their statements in regard to water, declaring that it is entirely elastic.

"It is further argued, that the slow vermicular motion, but ill represents the velocity with which sounds travel. In short, it is urged, that such undulations as have been described, when coming from several sonorous bodies at once, would cross, obstruct, and confound each other; so that, if they were conveyed to the ear by such means, we should hear nothing but a medley of discordant and broken articulations. But this is equally with the rest, contradictory to experience, since we hear the fullest concert, not only without confusion, but with the highest pleasure. These objections have given rise to another theory: which we shall likewise lay before the reader; though it appears also liable to objections, which shall be afterwards noticed."

* * * * * * * * * *

In the article on "Sound," in the same work, this subject is further discussed as follows:

"In the infancy of philosophy, sound was held to be a separate existence, something which would exist, although no hearing animal existed. This was conceived as wafted through the air to our organ of hearing, which it was supposed to effect in a manner resembling that in which our nostrils are affected when they give us the sensation of smell. It is one of the Platonic species, fitted for exciting the intellectual species, which is the immediate object of the soul's contemplation. Yet, even in those early days of science, there were some, and, in particular, the celebrated founder of the Stoic school, who held that sound, that is, the cause of sound, was only the particular motion of external gross matter, propagated to the ear, and there producing that agitation of the organ by which the soul is immediately affected with the sensation of sound. Zeno, as quoted by Diogenes Laertius (lib. vii. § 158), says, 'Hearing is produced by the air which intervenes between the thing sounding and the ear. The air is agitated in a spherical form, and moves off in waves, and falls on the ear, in the same manner as the water in a cistern undulates in circles when a stone has been thrown into it.' The ancients were not remarkable for precision, either of conception or argument, in their discussions; and they were contented with a general and vague view of things. Some followed the Platonic notions, and many the opinion of Zeno, but without any further attempts to give a distinct conception of the explanation, or to compare it with experiment.

* * * * * * * * * * *

"In the mean time, the anatomists and physiologists were busily employed in examining the structure of our organs of hearing. Impressed with the validity of this doctrine of aërial undulations being the causes of sound, their researches were always directed with a view to discover those circumstances in the structure of the ear which rendered it an organ susceptible of agitations from this cause; and they discovered many which appeared as contrivances for making it a drum, on which the aërial undulations from without must make forcible impulses, so as to produce very sonorous undulations in the air contained in it. These therefore they considered as the immediate objects of sensation, or the immediate causes of sound. But some anatomists saw that this would not afford a full account of the matter; for, after a drum is agitated, it has done all that it can do; it has produced a noise. But further process goes on in our ear: There is behind the membrane, which is the head of this drum, a curious mechanism, which communicates the agitations of the membrane (the only thing acted on by the undulating air) to another chamber of most singular construction, where the auditory nerve is greatly expanded. They conceive, therefore, that the organ called the drum does not act as a drum, but in some other way. Indeed it seems bad logic to suppose that it acts as a drum merely by producing a noise. This is in no respect different from the noise produced out of the ear; and, if it is to be heard as a noise, we must have another ear by which it may be heard, and this ear must be another such drum; and this must have another, and so on for ever.

"These anatomists attended therefore to the structure. Here they observed a prodigious unfolding of the auditory nerve of the ear, which is curiously distributed through every part of this cavity, lining its sides, swinging across it like a curtain, and sending off fibres in every direction, so as to leave hardly a point of it unoccupied."

Criticisms like the above in regard to the theory of Sound, generally accepted by the bookmen, we might quote by the hundreds, but will only add one more from the highest authority among those who have accepted these theories for the purposes of teaching. We refer to Ganot, author of the most able and widely circulated text-book ever published on Physics.

Mr. Ganot writes his book to sell, accepting those theories, which are more generally taught, but evidently in this case, perceiving their intrinsic worthlessness, he hedges against the future with the following statement (Chapter I., page 3, Fourteenth edition):

> "In our attempts to ascend from a phenomenon to its cause, we assume the existence of *physical agents*, or *natural forces* acting upon matter; as examples of such we have *gravitation*, *heat*, *light*, *magnetism* and *electricity*.
>
> "Since these physical agents are disclosed to us only by their effects, their intimate nature is completely unknown. In the present state of science, we cannot say whether they are properties inherent in matter [corpuscular], or whether they result from movements impressed on the mass of subtile and imponderable forms of matter diffused through the universe [undulatory]."

With this complete demonstration that the undulatory theories have never been verified, and with a sincere belief ourselves, which we know to be shared by many others, that they are utterly worthless, and indeed much worse than that, because standing in the way of real knowledge, we offer instead evidence that Sound is corpuscular which we believe to be unanswerable.

This places the Theory of Sound in harmony with Newton's Corpuscular Theory of Light, which is again being received by some of the best thinkers as correct, and which beyond any possible question is so.

Odor is known to consist of infinitesimal corpuscles of matter, as, in some cases, these have been discovered floating upon water. And so, unquestionably, corpuscles of Sound were discovered by Oersted and Wheatstone in studying the vibrations of plates.

That all the sensations have a similar cause is in the nature of a self-evident truth. Under 'Copernicus' the British Encyclopædia says:

> 'He sought by a comparative study of the various astronomical systems of the ancients to evolve from them a single system at once simple and consistent.'

"Thus arose the Copernican system, in which all the planets revolve around the sun, superseding the old Egyptian, in which Mercury and Venus revolved around the sun, whilst itself, with Mars, Jupiter, and Saturn, revolved around the earth. In this case the error of many centuries, which supposed the action of the planets to be controlled by different laws, was corrected. It is certainly full time that a similar error of equally long standing, which makes the senses governed by different laws, should be corrected."

INTRODUCTION.

WE have been repeatedly asked by thoughtful men who have become satisfied that the Undulatory Theory of Sound was a gross error, as much so as the old Ptolemaic Theory of Astronomy, to publish a book upon Sound which would thoroughly expose those portions of the present theory that are erroneous, and not be too bulky or expensive—something that would come within the reach of all.

When the last volume of "*Ellen*" was published, a book of over 900 pages, and the first volume of the American Stallion Register, of 1100 pages, was also finished and printed, there seemed to be an opening in which we could do this. And we are happy to say that since we left the Bread Loaf in October we have finished such a book, which is now in type, and will soon be published. The title of it is,

"THE NEW PHYSICS."

But although it treats on the principles of the new physics at several points; it is mainly taken up with a condensed but complete exposure of the errors in the present theory of Sound.

We wish to say in this connection, that,—whilst we have for years opposed all undulatory theories, as at variance with the fundamental principles of creation, and otherwise not only entirely, but very foolishly, erroneous,—none would more willingly give credit to the work of many scientists in investigating some of the principles of Sound, one of the most remarkable, useful and beneficent of nature's phenomena. We refer to such men as Oersted, Wheatstone, Savart, Latour, Duhamel, Von Helmholtz, Koënig, and perhaps many others, who with much labor and skill have looked up and successfully explained some of the most difficult problems connected with this science.

In our work upon this new book we saw the desirability of more knowledge in regard to the graphophone, and therefore arranged for certain experiments at Middlebury, with following results:

NO. 1.

The recorder was placed in contact with a blank cylinder, that is, on a paraffin and wax cylinder which had not been used for a record. The cylinder was not set in motion. Hallooing into megaphone, a well defined indentation was made shaped like the end of glass recorder, with pulverised paraffin and wax surrounding it. Reproducer run over indentation, two distinct sounds or ticks were produced, one for each revolution.

NO. 2.

The recorder was passed over a portion of cylinder without sound being uttered, forming only grooves; then the cylinder was stopped and the recorder placed upon the grooved surface.

The experimenter hallooed loudly into the horn without sensibly disturbing the air. The result was an indentation in the paraffin and wax across two grooves and up the next one.

On watching the recording stylus with a magnifying glass, the pulverized paraffin and wax was seen to rise up and accumulate about the point as long as the sound continued. Reproducer run over it, gave three distinct sounds or ticks, one for each revolution of cylinder.

NO. 3.

Recorder resting on blank cylinder in motion, loud halloo in graphophone; result, well marked indentation on cylinder except near beginning and end of sound, where slight groove shows with light indentations; record shows that the sound continued four complete revolutions of cylinder.

NO. 4.

A few grooves were formed on cylinder; the recorder was placed on a groove, the cylinder being stationary; A, B, C were spoken into graphophone not very loudly; an indentation was formed extending over one groove. Reproducer run over it, gave only ticks.

NO. 5.

The letter A was pronounced quickly into the horn, the cylinder rotating, and the result was a record extending over about one-half a circumference of the cylinder, the indentations being alike in form.

On uttering B and C, the indentations were alike for the same letter; but those of one letter were different from those of each of the others. In each case the record extended over about one-half a circumference, which means quite a large number of indentures made in the production of each letter. This suggests the explanation of the different *qualities* or *color* of Sound; for though similar, the indentations at the beginning and end of the letter were not so deep as those made in the middle of the letter, and probably all these indentations vary a little.

NO. 6.

Experiment similar to the last except a cylinder was used which had been previously grooved. The letters were spoken loudly, B and C being loudest. The result was well marked indentations on cylinder. B produced the deepest ones, making three indentations and a skip of about equal length, then four indentations, the two middle ones deep, the two outside ones not so deep, followed by another space, each letter occupying a little over half a revolution. The unequal indentations with skips occur near the middle of the letter. Reproducer gave very distinct sound of each letter, that of B a little rough.

NO. 7.

Recorder resting on blank cylinder in motion, a few bars of "Home, Sweet Home," were sung into megaphone with continuous and strong voice, and at same time an ordinary dinner-bell was rung vigorously a little back and to one side of singer. Result, a good record of song, "Home, Sweet Home," but none whatever of the bell.

NO. 8.

Recorder resting on blank cylinder in motion; ordinary dinner bell rung vigorously into megaphone: result a fairly good record, when repeated by the reproducer.

NO. 9.

Three skilled musicians played a Grand March, with piano, violin, and cornet. The result was a fairly good record of all parts, but that instrument that was the loudest at any particular time seemed to predominate over the others in that portion of the record.

NO. 10.

The cornet and violin played at the same time different tunes in different keys, the piano accompanying the latter in a different key, and, in spite of discords, a fairly good record was obtained of each instrument.

It is suggested in "*Ellen*" that the indentures are made by the different sounds themselves conducted by the diafram and stylus into the paraffin and wax. This view is taken to avoid the apparent difficulty of several records being made at the same time,—as when an orchestra is playing,—by the operation of the resultant of several forces.

We have seen no criticism of this explanation in "*Ellen*," nor has any been made to us. But the above experiments show that the stylus moves or vibrates—for, lifting the recorder up when the music was playing, including the cornet (quite a powerful instrument), and holding our finger against it, we could feel the vibratory movement; and it is quite possible that it alone carves the indentures; although the sounds which are uttered into the megaphone and enter the diafram, it would seem, must pass to the recorder and then into the paraffin and wax. In case the records are made by the recorder, they are not complete, but only such as may be taken without violation of the law of resultants; that is, no fundamental law is interfered with. Quite possibly the effects of the sounds linger in the mind as those of vision do.

There is still some question of doubt in regard to how the record is made, but none whatever that it is made by the sound uttered into the megaphone; and none whatever that it is made by the principle of motion, which this sound inherits from its ancestors; that it is born with, and carries with it through all its wanderings, whichever way it travels, or however it travels; and which acts as a sensitive plate to record disturbance, and does record it as perfectly as the retina records pictures,—for Sound in its essence is an acoustic picture,—and conveys a copy to sentient beings.

In all the forces of creation, no other thing can do exactly this. The disturbance produces Sound, which not only has the power of movement, but under favorable circumstances can make an instrument, that, when agitated, will recreate the sound, diminished in force, but capable of performing, and for the purpose of performing, some other important function, perhaps if not probably for use in the records of memory,—the memory of sounds.

Thus a disturbance is easily photographed upon the surface of water, from the shimmering undulations of a gentle breeze, to the vast waves of a destructive storm. And so the pictures of disturbance, which constitute Sound, are prepared for the market through the vibration of the body in which they are made, and are themselves infinitesimal particles of matter in motion. But in all such cases, results are produced by contact of matter with matter.

THE NEW PHYSICS

SOUND

I.

SOUND is one of the most remarkable phenomena of the world, and doubtless of the universe. Its principal object would appear to be the dissemination of knowledge among intelligent creatures, and in this category all things having intelligence, whether little or much, are practically included.

In material conditions all instruction of intelligent beings is accomplished through the sensations, and Sound is one of the principal sources of sensation. Its value thus in the furnishment of the universe becomes most evident. It might be dispensed with, as it has to be with those who are entirely deaf, but without it the system of the world's education would be seriously incomplete.

In addition to its more strictly utilitarian uses, Sound holds a conspicuous part in the æsthetics of the universe, there being hardly any sounds but what are contributory to these, and many of them remarkably so. Thus we have the music of the birds, of the forest and of the ocean, of mountain streams, and of the human voice. In utilitarian lines is the great convenience and delight of conversation. So that it may be easily seen that if there were no sounds it would be to the very great loss of this wonderful universe. To those who had been accustomed to them a large part of its attractions, as well as instruction, would be gone.

In studying the nature of the universe it becomes evident that throughout it is constructed upon mechanical principles, from the largest sphere to the most delicate cloud or flower.

By intelligence its different features are formed, placed in their respective positions, and fitted for their various uses. There are no exceptions. The Intelligence which planned it was equal to its fullest conception, and all things conform to the laws of usefulness and beauty.

Among these, and one of the more important of them, is Sound.

The mind of man is doubtless able to understand the laws by which every material thing is constructed. And therefore as soon as these laws are discovered there should be no doubt in regard to them. There has always been great doubt, or great ignorance, as to the nature of Sound, although it is impossible to see any good reason why there should be. In the case of light Newton studied the matter carefully and became satisfied that it consisted in infinitesimal particles of matter thrown off by illuminating bodies. And he was right. And so, too, odor consists of infinitesimal particles of matter thrown off by the odoriferous body, which is accepted by all, as it is possible in certain conditions to see the particles with a microscope. Because of the Universality of Natural Law, it follows that Sound, a third source of similar sensations, consists of infinitesimal particles of matter thrown off by a sounding body. It will be readily perceived by a thorough study of the different phenomena of Sound, that by the corpuscular theory every phenomenon or operation of Sound is fully explained,—as always in any theory they should be if the theory is true,—and it is equally true that by no other theory ever suggested can any of these—not a single one—be satisfactorily explained.

UNIVERSALITY OF NATURAL LAW.

"Order is Nature's First Law," and therefore if we wish to learn about any particular phenomenon, we can easily do so by comparing it with similar phenomena of which we have knowledge.

Thus we have plants, and certain things are true of all of them. They derive their sustenance from matter and are propagated by seed or cuttings. There is no other way.

And so animals, whether large or small, have life, and motive power. They also derive their sustenance from matter; and each variety reproduces its kind, and can reproduce no other.

The endless variety of sounds are, too, made by sound-producing instruments, either natural or artificial. There is no other way; but nearly every body may be a sound-producing instrument.

And every instrument makes one particular sound, and can make no other, unless it be a compounded instrument, as a piano, made to make several sounds, in which case it can make these several sounds, and can make no others. That is, any instrument can make the sounds it was made to make, and no others.

The suggestion that a diafram, or any other thing, could make the different sounds heard at a receiving telephone, which practically means all the sounds in the universe, is just as ridiculous, and similarly so, as that a plant, any plant, could produce every plant in the universe, or an animal, every animal.

There is but one power that can do this, and that is the highest Intelligence. God alone can create all the sounds of the universe, the plants, or the animals. And He has created them all, in accordance with certain laws, in which, so far as we are concerned, certainly, there is no variance or shadow of turning.

These facts being so self-evident, it is of course extraordinary that any one should have adopted the explanation given by scientists of the action of Sound at a telephone, that it is all made by the diafram, or some other part, of the receiver. We think no one could have done it if he had seriously considered what it meant. But the telephone came so suddenly and was so novel that many lost their judgment. Again, there could have been no such explanation except for an erroneous Theory of Sound. This subterfuge alone offered to save that theory, and in the wonder of new and most remarkable discoveries it was made to float for quite a time. The world at large are always ignorant of such subjects. In this case, first came the telegraph, then the telephone, followed almost immediately by something which seemed far more wonderful than either—the graphophone. By this time the great majority of folks were prepared to believe almost anything that was claimed for either Electricity or Sound.

But though all these phenomena connected with electricity and sound came together, and for a while demoralized ordinary judgment, the true connection between them, or the possible accomplishment of each, with the lapse of time is becoming entirely evident. It was natural enough at first to suppose that sounds made at a telephone receiver were made in some similar manner to those of the graphophone, which last was an entire enigma, seeming to suggest that Sound like water might issue from any unknown source. And under such conditions it was not difficult to advance any explanation, possible or impossible, for those heard at the telephone.

All our previous knowledge was that Sound was made by sound-producing instruments, made for the purpose. Nor did any one ever conceive any other origin for it. If the sound of a jewsharp was wanted, a jewsharp was made to make it. The same was true as to all artificial sounds. And as nature is known to be far more skilled than man in the creation of things; and also as it is understood that man in his inventions makes use of the principles and material used in nature, and can make them in no other way; it followed that artificial sounds were similarly made. That is, they were made by instruments designed to make them, or which included in their design the power to make them,—and that means the principles necessary to make them. Here was a method of supply sufficient for its purpose, and satisfactory to the mind. For it harmonized with the perceptions of intelligence, and the universal order of creation; just enough arrangement to produce the result sought with no waste.

The idea that all sounds could be made equally well by anything, whether made to make them or not,—that is, whether it included the principles necessary for their production or not,—as an iron core, diafram, coil of wire, bar, curbstone, fireplace, or chimney, all of which are specified in scientific experiments as making them (See "Ellen," Vol. II., pages 478, 479), originated entirely in a fake theory of Sound, and will have to be swept out with the theory. For the graphophone, instead of pointing to any other method for the manufacture of Sound than that which has always been accepted, is another illustration of that method.

The graphophone record is itself made by Sound, and when played upon will repeat the sound which made it, which is the sound it was made to make, and it can make no other.

For all material things are made for a purpose, and can accomplish that purpose, but only by the methods provided for doing it. They are themselves utterly helpless to do anything except what they were made to do, and that means what they have the machinery to do.

A fundamental law of Sound is that every body has a normal vibration. The scientists say every elastic body, but their definition for elasticity is so varied that it is hardly worth considering.

But still further is the universality of natural law illustrated, for all sound instruments remain as silent as the grave until the principle of their use is brought into action,—something to play upon them. That is, there must be shock. For this is as indispensable a feature in the creation of Sound, as soil for the development of seed, or food for that of animals. All of this now is easily perceived by a little careful study, and is fully explained in "Ellen." And these infinitesimal instruments made by Sound are just as capable of uttering their music, when the proper machinery is set in motion, as the largest organ, and this, whatever the cause of their infinitesimal appearance. They look small to us, but what that signifies we do not know. They will make the sounds all right, which, in form, are certainly infinitely smaller than they. And the megaphone will magnify these sounds so that they may equal those of the larger instruments.

With this further instruction showing the unchangeableness of the laws of nature, we learn that all sounds heard at the telephone are made where the sound-producing instruments to make them are situated. And this means, in the case of persons, where the person is, the intonations of whose voice are recognized.

The two principles, then, in the manufacture of sounds are, first a machine, whether large or small, fitted to utter a certain sound, and this is represented by any so-called elastic body, and second, shock or disturbance, to produce the sound which the instrument was formed to utter.

The above principles are in universal application in the production of sounds. And they are just as certainly connected with the sounds of the telephone as with any other. Nature uses no superfluous causes. Her creations enter into every conceivable want, but there is no useless work in them. They stop when their object is accomplished.

Nature's plan then is that every sound-producing body makes whatever sound or sounds it was made to make, and no others. The scientific explanation of the action of Sound in a telephone is that every so-called elastic body may make, and indeed will make, every sound in the universe.

For if a diafram is made to vibrate so as to repeat all sounds, every body into which sounds enter, and that means nearly or quite all bodies, must do the same, and thus be engaged indefinitely in producing all sounds, often striving hard to make a number of sounds at the same time, of course making a dismal failure, although if it was possible that any one of the fundamental laws of nature like that of Sound, or Light, or odor, being made by instruments or things made to make them, could be violated, all might be, and a body or thing or person—any body or any person—might as well make several things or any number of them at the same time. That light is made by bodies made to make it, as the sun or a lamp; or odor by things made to make it, as a sweet pea or water lily,—that is, by things having light-making or odor-making machinery, and that they can make no other light or odors than those they were made to make, or have the machinery to make,—is no more true, than that nothing can make Sound unless made to make it, or any sound except what it was made to make, and that means any unless it has the machinery to make it. In this way, one of law and order, is the Universe made, nor can we see how it could be made without law and order. You cannot gather grapes from thorns or figs from thistles.

In this un-scientific explanation of the action of Sound at a telephone, we have the assumption that all the sounds of the universe are made without any means whatever to make them; that is, that the wires, sounding board, or keys, are not necessary to the music of a piano, but that this music could be got just as well from an iron post, or a rail fence.

Instead of any such universe as this, there is one of great magnificence and perfection, made by the Creator who makes every particular thing for some purpose, and ordains that many things should have the power to perpetuate their kind, but here their ability to create ends.

Sir Isaac Newton in Book III. of the Principia, under "Rules of Reasoning in Philosophy," with great force and truth, says:

RULE I.

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity and affects not the pomp of superfluous causes.

RULE II.

Therefore to the same natural effects we must, as far as possible, assign the same causes.

RULE IV.

In experimental philosophy we are to look upon propositions collected by general induction from phenomena as accurate or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions.

This rule we must follow, that the argument of induction may not be evaded by hypotheses.

II.

SOUND, like light and odor, is composed of infinitesimal particles of matter. It is made by shock or disturbance, generally dissipated at once, but, under certain conditions, may be retained by metals, or tense strings, and possibly some other substances. When retained in a body it causes vibration, and is itself thrown off by this vibration, that is, by the sounding body. Evidently it lingers in the metal or tense string because unable to get out, except with difficulty, and therefore slowly; and doubtless if the metals or wires extended an indefinite distance, the sound would follow them at once, and disappear.

These principles are demonstrated by a tuning fork, the sound in which is made by a blow, or shock, and immediately causes the fork to vibrate, apparently—for it is very difficult to see how else it would do it, certainly how it could do it so easily—by circulating through its interstices.

The interstices are similar for forks which make the same sounds. That they are similar is proven by the principle of sympathetic vibration, where Sound created by one fork will pass perhaps through the air, but certainly by wood, and entering a unison fork, that is, one having normally the same vibration, will cause that to vibrate, and emit the sound that the first did.

That is, the sound made in the first fork by the blow or shock, and moulded into form by the machinery of the fork, enters the second, which, having the same interstices, acts as a receptacle for gathering this kind of sound. It will, too, emit the sound in the same manner as the first does. Thus a stove will gather and radiate heat, and in a similar way the diafram of a telephone will gather and throw off sounds, or perhaps a moon, light. The stove cannot make heat, or the diafram, sound, nor the moon, light, any more than thorns can bear grapes, or thistles figs.

The decrease of vibration in the first fork is equable, precisely so and always so, from the time of shock, when the sound begins, until the last of it runs out, or is thrown off. It is, then, certain that the blow makes Sound; certain that the sound is immediately emitted by the fork, and decreases with perfect regularity until it ceases. It is also certain that the sound will run away far more rapidly if the stem of the fork is placed upon some conductor, as wood.

Other things being equal, Sound spreads in the atmosphere in all directions from the sounding body. In many substances it is partially confined, and in some, as a wire, wholly so, in its course. That is, it does not spread, but goes straight ahead. Lord Bacon, says:

> " It is evident, and it is one of the strangest secrets in sounds, that the whole sound is not in the whole air only; but the whole sound is also in every part of the air. So that all the curious diversity of articulate sounds of the voice of man or birds will enter at a small cranny unconfused."

There is just one way, and only one way that this could happen, and that is, that the sound was infinitesimal enough for it to happen. In other words, this fact is another demonstration that Sound is corpuscular, infinitesimal particles of matter. If anyone will insert a needle into one end of a short stick, and place the point upon a sounding board, upon which the stems of several tuning forks in motion, rest, and the other end of the stick in the teeth, he will find that the sounds of the different forks will instantly ascend the point of the needle, and through the teeth immediately reach the auditory nerve. These sounds do not mix. It makes no difference upon what part of the sounding board the needle is placed, they will all ascend the point at the same time, but not one of them will ascend at all, unless the point of the needle touches the board.

It is equally certain that the sound which is thus thrown off, or runs away from a fork, will enter the ear, creating the sensation of Sound; or enter another similar fork, and no other,—at least no other unless it is of the same tone or very nearly so, and not in the largest quantity, unless it is entirely so,—which it makes vibrate. Here is vibration without shock or friction. But if this sound is the cause of this second body's vibration, which it certainly is, it holds to reason that it was the cause of the precisely similar body's vibration which it left. And, these facts being so plain, it is most astonishing that erroneous views connected with them, utterly senseless, should have been in vogue for centuries. Thus strike the fork (any tuning fork), and place the stem upon one end of a small stick (spruce very good), holding the other end in the teeth, or against the forehead. The sound will run rapidly and in large quantity from the fork into the head, where it is plainly heard, and this sound has never passed into the air, and of course has nothing to do with air waves, or any other waves. And this is the explanation of sympathetic vibration, so simple that the wayfaring man though a fool could not err therein, although for over 2,000 years it has been unexplained.

It was proven by the great electrician Oersted nearly a hundred years ago that Sound is electrical. And therefore vibration is made by an electric force.

Pitch is determined by the amount of Sound of a certain character heard in a certain time.

The intensity of Sound depends upon the force which makes it, infinitesimal particles of moving matter, undoubtedly electrical, aroused by the shock, upon which also depends the length of the vibrations, which themselves otherwise are controlled by the character of the body in which they take place; and these vibrations of a particular body, that is, of each particular body, are the machinery which decide the character of every Sound.

And thus the different brands are formed, similarly as the different kinds of lumber, as boards, plank, staves, are made by a saw-mill; or different kinds of goods in any factory although neither the lumber from which the boards are made, or the cotton or linen, or any other material from which such things are made, is made by the mill. These come from the outside.

Every hard body will produce Sound when struck by another hard body. Most of these sounds are instantly scattered, but certain instruments are in their nature sound-containing, just as there are certain bodies, as oceans, lakes, or ponds, water-containing; and others as suns, stars, lamps, or candles, light-containing. And as the water-producing bodies consist of those which contain deposits of water; or light-producing ones, those which have deposits of light, however these be made; so sound-producing instruments consist of those which in some way have deposits of sound.

But all water, however it may be stored or carried, is composed of oxygen and hydrogen, a mixture of matter in certain proportions; so all light and all sounds, as well as everything else in the material universe, are made from matter. For although fluids or gases appear quite differently from solid substances, the laws of their combination are similar, that is, they are all composed of matter. And therefore, the differences of sounds, like those of odors, and everything else in the material universe, must consist in the materials from which they are made, and the manner these are mixed. This law is a very simple one that every scientist should understand. Nor is it possible for him to be of any use in such matters until he does.

All Sound is active. The sound which circulates in a tuning-fork, causing it to vibrate, acts very similarly to that which, entering a vault or a large church, reverberates. It is in the nature of Sound from its inception to scatter in all directions, or to try to. When held back as in a fork, or wire, or sounding board of a musical instrument, these act as a reservoir of sound, as before suggested, from which it is thrown off or distributed continuously while it lasts.

To the mistaken idea that vibration makes sound, is in part due the theory that the diafram of the receiving telephone repeats the sounds uttered at the sounding instrument; whilst it is forgotten that millions of vocal organs and other instruments are required to make these sounds, which are supposed to be thus repeated, and that all these have the necessary machinery to make them, nor could they possibly make one of them without it, nor can anything else make one of them without it.

In a recent Middlebury (Vt.) Register was published in part a two column article, from the New York Sun of Sunday, August 30th, sent by a correspondent from Cambridge, Mass., portraying, vividly, Newton's corpuscular theory of light, and naming a number of eminent physicists of different countries who are zealous advocates of this old theory, now fully revived.*

The corpuscular Theory of Sound must soon follow, when at last nature's great system of creation, in which every material thing is made through a mixture of matter, will be accepted in its entirety.

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* See Appendix.

III.

WE have spoken of the origin of sound—a blow or shock, by which the proper mixture of matter is made to produce the different sounds. And Sound thus made has within itself the power of motion, and circulates with wonderful facility through many different channels, its mission being to produce in man and other animals the sensation of hearing. And this it does, and does only, by entering the body, thus coming into contact with, or into the immediate presence of the soul. For it is the soul only that can feel or think.

The entrance of matter into the body is the one law by which the soul becomes acquainted with material conditions. Every material thing thus introduced affects the body in some way, but no material thing affects it unless so introduced, or brought into contact with the body by touch.

Thus any article of food taken into the body affects the soul, as well as the body, although in a very different way from sound or light. But neither the food, sound, or light affect it at all, except as introduced to it by the machinery of the body.

We mention all this because it all has a bearing as to the nature of Sound. There is only one possible way in which Sound could give instruction to mind, and that is, first, that it is a substance composed of matter; and second, that it enters the body. And this because of nature's unalterable laws.

Again all vision depends as much upon the capacity of the eye to see, as upon the arrangement or nature of things seen.

Man has a beautiful range of vision, and can see many wonderful things; but there are myriads of beings with ability to see, and unquestionably the scope of that ability varies with each different species.

But all of this difference in vision takes place because of the laws which make any vision possible, which laws concern both the things seen and the eye seeing. The moral of which is that myriads of things, invisible to certain eyes, are visible to others, among which, unquestionably, are the particles of Sound —as plainly visible through some eyes as drops of water to ours.

The microscope illustrates how, by the rearrangement of the visual angle, things invisible become visible. And so, too, the telescope makes possible the perception of things that without it would be forever invisible to man.

From this, again, we can see how utterly senseless it is to suppose that nature changes her laws of action, where the limit of man's vision prevents him from seeing their operation. This subject is very fully treated in "Ellen," Vol. II., pp. 75–84, inclusive.

A modern writer most forcibly says:

> "All things in their basic principles resemble all other things, and we are safe in judging of the unknown by the known, of the invisible by the visible, and of the whole by a part.
>
> "Shall we fight against all analogies in the mechanics of nature and man to carry out a theory? Shall we not reason from the known to the unknown in harmony with nature's infinite unity? Shall we trample upon this great law of things by means of which a thousand mysteries may be cleared away and a host of new truths discovered?"

In the Encyclopædia Metropolitana, Sir J. H. W. Herschel speaking in the interest of Dr. Young's undulatory theories says:

> "If the axis of the fork, or the line to which it is symmetrical, be held upright about a foot from the ear, and it be turned round this axis while vibrating, at every quarter revolution, the sound will become so faint as scarcely to be heard, while in the intermediate axis of rotation it is heard clear and strong. The audible situations lie in lines perpendicular and parallel to the flat faces of the fork, the inaudible at 45° inclined to them. This elegant experiment, due originally to Dr. Young, has recently been called into notice by Weber."

It is true that if a sounding tuning fork is turned about the ear the sound varies, which is explained by scientists as a wonderful demonstration of the extinguishing of sound waves by the interference of one wave with another, and is indeed supposed to be one of the principal proofs of this undulatory theory, although the true explanation is that Sound is thrown off from the flat part of the fork, much faster than from its edges, as in the nature of things it must be; and is alone a demonstration that Sound is composed of particles of matter. Thus if the nozzle of a pipe through which water was being thrown, was turned towards the ear, more water would be thrown into the ear than if the nozzle was turned from it. It is impossible to conceive of anything more self-evident.

Professor Silliman of Yale College, in Principles of Physics, published by him, says:

> "Length of Sonorous waves.—It is easy to ascertain the length of a sonorous vibration, if we know the number of vibrations made in a

second. For, as sound travels at the rate of 1118 feet per second, if but one vibration is made in that time, the length of the wave must be 1118 feet; if two vibrations, the length of each must be half of 1118, =559 feet, &c.

"C corresponds, as we have seen, to 128 vibrations per second; the length of its waves, is therefore, (1118÷128)=8.73 feet.

"The following table indicates the length of the waves corresponding to the C of successive scales:

	Length of waves in feet.	Number of vibrations in a second.
C-3	70.	16
C-2	35.	32
C-1	17.5	64
C 1	8.73	128
C 2	4.375	256
C 3	2.187	512
C 4	1.093	1024

Mr. Ganot says:

"The wave length of the sounds uttered by a man's voice in ordinary conversation is from eight feet to twelve feet, and that of a woman's voice, from two feet to four feet."

All books of physics agree as to the length of these waves. Indeed the whole theory depends upon them. And, to produce Sound, by the theory, they must enter the ear, every ear, without disarrangement; an absolute impossibility.

But all will agree that if it was possible for them to form, there must be room for them to form in. That is, there must be at least 70 feet of space for the longest one, between the sounding body and the ear, the others proportionally. But, as every one can learn by experiment, there isn't a sound thus represented but can be heard perfectly, uttered close to the ear, with less than three inches between it and the auditory nerve. This fact alone shows the utter absurdity of the whole theory.

Again the lengths of these hypothetical waves as above given are only for those made in air. But as the speed of Sound is much faster in many mediums than in air, such waves in them would be proportionally longer. Thus in hydrogen about four times as long; in water something more than that; lead about four times; gold and silver about eight times; copper over ten times; ash or walnut about fourteen times; steel wire or wrought iron, fourteen and one-half times.

That anything in the shape of waves 70 feet long, or one foot long, or of any length, could circulate in air, in all directions, and in all times, or in fact at any time, the radius of a sphere, thus entering ten thousand different ears, more or less, without in the slightest changing their form is an inconceivable absurdity. And frequently there are thousands or tens of thousands of different sounds thus circulating at the same time, in the same space. But if this undulatory theory was true, these so-called air waves would have to do this in all kinds of weather, and against the most formidable opposition of competing sounds, and many other occurrences.

As a matter of fact, because of the mobility of the air, it would be impossible for air particles to ever form themselves into these so-called waves, or pulses, as Newton accurately called them, for waves belong to the surface and are impossible in the body of a fluid. Newton says:

> "If the medium be not elastic, then, because its parts cannot be condensed by the pressure arising from the vibrating parts of the

tremulous body, the motion will be propagated in an instant towards the parts where the medium yields most easily, that is, to the parts which the tremulous body would otherwise leave vacuous behind it. The case is the same with that of a body projected *in any medium whatever*. A medium yielding to projectiles does not recede *in infinitum*, but with a circular motion comes round to the spaces which the body leaves behind it. Therefore as often as a tremulous body tends to any part, the medium yielding to it comes round in a circle to the parts which the body leaves; and as often as the body returns to the first place, the medium will be driven from the place it came round to, and return to its original place. And though the tremulous body be not firm and hard, but every way flexible, yet if it continue of a given magnitude, since it cannot impel the medium by its tremors anywhere without yielding to it somewhere else, the medium receding from the parts of the body where it is pressed will always come round in a circle to the parts that yield to it"

Wire is especially an excellent medium for conversation, as illustrated by the toy or box telephone, but by this theory, for some of the sounds, there would have to be a length of nearly ¼ of a mile, to enable the "70 feet in air wave" to materialize. But the conversation can be carried on within a very short distance. Isn't it about time for everyone to give up a theory so self-evidently absurd?

IV.

THE only possible explanation of an ear trumpet is that Sound is poured into the ear as grain into a hopper. The action of the ear trumpet alone is a demonstration that sound is corpuscular. Again the idea that any kind of wave could be reflected so as to form echoes is inconceivable to any one with a single grain of common sense; it being admitted, as it is in all text-books, that any part of such wave,—some of which, as we have seen, are supposed to be over 70 feet in length, and all of them of considerable length,—represents a certain quality, and the whole wave, what is called the correlative without of Sound.

Deschanel says in his text-book of Physics:

> "Character or timbre, which we have already defined, must of necessity depend upon the form of the vibration of the aerial particles by which sound is transmitted, *the word form being used in the metaphorical sense, for in the literal sense the form is always a straight line.*"

The part of this sentence in italics is incomprehensible, unless it is intended as a suggestion of the contradictory and impossible character of the theory. Ganot says:

> "The *timbre* or stamp or *quality* is that peculiar property of note which distinguishes a note when sounded on one instrument from the same note when sounded on another, and which by some is called the *color*. Thus when the C of the treble stave is sounded on a violin and on a flute, the two notes will have the same pitch; that is, they are

produced by the same number of vibrations per second, and they may have the same intensity, and yet the two notes will have very distinct qualities; that is, their timbre is different.

* * * * * * * *

"If we were to represent graphically a compound note, we should proceed to construct a curve out of simple notes of different intensities. It is evident that the resulting curve will take different *forms* according to the presence or absence of different harmonics and to their different intensities; in other words, the quality or timbre of the notes produced by different instruments will depend upon the *form* of the curve representing vibrations producing the sound."

Exactly what Ganot means by "the curve representing vibrations producing the sounds" is difficult if not impossible to tell. He might mean the facts, the real machinery, back of the real sounds, following his still more remarkable statement at the beginning of his famous text-book on Physics, which declares the essential nature of Sound completely unknown.*

"Vibration of aerial particles by which Sound is transmitted" is reasonably perspicuous, as, considered in connection with the usual explanation of the theory, evidently referring to supposed air particles; but how such form could possibly retain its character until it had delivered its message to the soul within, the function and only function for which it exists, is again inconceivable. That particles of matter should retain their character until their purpose is accomplished, is wholly in accord with the known operations of nature. It will be seen that one physicist here talks about the form of the *curve*, whilst the other says the form is always a straight line.

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* See Preface, page ix.

Professor Pietro Blaserna in his theory of Sound, says:

> "The third characteristic difference of musical sounds is their *quality* or *timbre*. Suppose that the same note is sung by different human voices, and played on the pianoforte, violin, flute, etc., it does not require a delicate musical ear to recognize that these notes, although of the same loudness and pitch, are nevertheless different from each other. Our ear goes even farther in this direction, and not only distinguishes between violin and flute, but even between one violin and another by a different maker. The difference is very marked, and makes itself felt in a most remarkable manner in the price of the instrument.
>
> "The difference of *timbre* is therefore very important, and very characteristic. In the human voice, which constitutes the most agreeable and richest monotone musical instrument, the variety is immense. There are scarcely any two individuals who have exactly the same *timbre* of voice. *Timbre* and inflection are the safest means we have of recognizing a person.

This author also tries to suggest a difference in form of oscillations to account for *timbre*. Oscillations of what, he does not say.

Rev. James Challis for many years Professor of Astronomy at Oxford University, England, says:

> "The possibility of hearing distinctly words spoken at a distance, depends on the faithfulness with which the air transmits the impressions made on it by the organ of voice. As the difference between the sound of one letter and that of another corresponds to a difference in the form of the curve representing the succession and magnitude of the condensations impressed, it is necessary that the form should remain unchanged by distance of transmission in order that words heard at different distances may be the sounds. The law of transmission ex-

pressed by the formula $a + v$, which is the basis of Mr. Airy's speculations, is opposed to this constancy of form. M. Biot, however, has recorded an experiment made at Paris, according to which, words pronounced at one end of a cylindrical tube 3,120 feet in length were perfectly distinct at the other end."

The correlative without of vision is the thing seen; and the slightest defect in this will appear in the vision. Thus in an elm tree, if a single branch or leaf is gone or the smallest part of a leaf, the vision, that is, the picture in the eye, will be defective to the same extent. That a similarly exact correlative exists without, of Sound, there can be no possible question.

Sound is always made by shock or friction, and takes place throughout the world, and, so far as we know, the universe. It may be produced by all elastic bodies, and some as water which formerly was called not elastic, but is now for the sake of harmony, called entirely elastic; the truth being that the so-called elasticity of bodies doesn't enter into this question of Sound in the slightest, excepting to give the scientists something to talk about. That is, most bodies, and perhaps all, if struck, will make some sound, and each body always makes the same. The great principle in the manufacture of Sound is that every body has its normal vibration, and therefore will always produce the same sound, and can produce no other. A second great principle is that different sounds do not mingle; and as heretofore mentioned, they can be conducted to the same sounding board, and different varieties at the same time will spread over that, and ascend from it—all at same time—a point of the finest needle, placed anywhere in contact with the board;

but instantly the sounds stop, if in any way their supplies are stopped, which may happen by the instruments making them ceasing to do so, or the connection being removed between these instruments and the sounding board.

Sound always consists of infinitesimal particles of matter, thrown off by the sounding body, or bodies, which particles are provided with motive power that enable them to circulate readily and quickly in all directions.

We may be able to see the disturbance from which the sound comes. With continued experience several things are certain: that the cause of the disturbance sometimes, as in explosions, is thrown upward and outward for quite a distance, but generally does not move far; and often, as in men or animals when talking and singing, not at all; second, the same or similar causes produce the same or similar sounds; third, there is an observable time between the occurrence causing the sound, and the sensation of hearing; fourth, so far as we can see, there is always a correspondence or similitude between the disturbance and the sound as heard. Thus if a man at half-a-mile distance alternates rapidly between striking a drum and blowing a bugle, the sound arriving at the ear alternates in a precisely similar way; and so any possible variation in the producing disturbance is reflected by the sound, just as much so, and just as certainly so, as the picture of a tree or any other thing is reflected in vision. For the one sensation is as perfectly made as the other. Any disturbance which produces sound, impresses its characteristics with absolute fidelity upon the sound produced—which immediately, or very soon after, finds its way by our ears into the auditorium of the soul, affecting it in such a way that it knows or may know the source of the sound,—and this because the same body always makes the same sound,—and if the sounds represent words that by previous instruction the soul has learned to understand, it may get valuable information.

V.

IT becomes certain that this substance caused by the disturbance, and which we know as Sound, must be infinitesimal, because it is invisible and cannot be felt. It must, too, be of such form that it could convey the impressions uninjured to the different intelligences that its mission includes. It would be impossible, as we have shown, for air-pulses to accomplish anything of this kind; first, because of the mobility of the air; second, because frequently there is no room for them as demanded by the theory; third, because they couldn't possibly retain their form through the distances they would have to go, or indeed, through any distance; fourth, it would be impossible for the vibrating body, as a tuning-fork, to cause particles of air for a single instant to go with the rapidity of sound. None of these things could be done without violating the fundamental laws of nature, and these are never violated.

But even stronger than these objections, any one of which is fatal to the pulse of air theory, is the fact, that nowhere is nature known to influence mind by any such method, but always by a combination of matter made for the purpose, as much so as a doctor's prescription. She can, by touch of the body, arouse the conception of the mind; but this is a result of pressure and evidently done by infinitesimal particles of matter, which, by the nerves, find their way to the soul, and thus by the sensation of touch deliver further information, often very important, to the individual, whether man or beast. For all of these provisions, like the rain, fall upon the just and the unjust.

The tree is the correlative of vision, light reproducing it in the eye. But Sound is the cause of hearing, the same disturbance always, to the slightest tone, making the same sound. In both cases infinitesimals are at work, and in both cases their work may be reduplicated indefinitely. That is, pictures may be reflected indefinitely, provided there is light, with proper facilities; and Sound can create instruments which will recreate a similar Sound, which process with proper facilities may be repeated indefinitely.

But though there is a sharp distinction between these two sensations, they are alike in this, that they each accurately report phenomena of nature to mind, and this work by both we may call very perfect and equally well done.

The tree doesn't make the light. The disturbance does make the sound. The picture made by the light is a perfect representation of the thing copied. And the sound made by the disturbance faithfully varies with the disturbance, and as faithfully conveys these variations to the soul. And this, as we have shown, with education, results in a new method for the obtaining of knowledge. It is a system of instruction general throughout the universe, at least throughout that part of it with which we are acquainted. Through it conversation is possible, with all the information which it commands, and also telegraphy to hasten such information.

And all of this is very easily done, not in the absurd and impossible ways undertaken by scientists, but by a comprehensive scheme vast as the universe itself by which certain disturbances produce certain results, and these results, being adequately provided with the power of movement, of necessity again perform their parts of circulating over a certain space, and especially entering the ears of all sentient beings in their path, where, following the auditory nerve, their message is delivered to the soul, and probably a graphophone record of it made in the brain.

There are no mistakes in the machinery of Sound; from the time it is started till it ceases to act it performs its functions with complete accuracy. A babe might not understand these signals, but those who have lived long enough in material conditions do.

And continually over the universe the signals are sounding, so that all who have the faculty of hearing are connected intelligently, and, as a mere matter of pleasure,—for nature provides for the pleasures of life, as well as for its necessities,—if so inclined, may listen to the sweet melodies of many sounds.

We know that a similar sensation, that of odor, is made by a chemical mixture of matter, in the form of infinitesimal particles, these being brought from the odoriferous body into the nostrils. In addition to this, so far as we have knowledge, every effect experienced by mind is directly attributable to the admission of matter, in its different conditions or combinations, into the body, where it accomplishes its special mission, and there are hundreds of thousand of things created or formed from matter which do this, although the methods by which they reach the soul may be very different.

We have already spoken of this, but these great laws of nature, by which the universe was constructed and through which it is continued, cannot be too well understood.

Thus, fruit, vegetables, provisions of all kinds, affect the soul, and nature has different ways by which these effects are accomplished, but they are alike in this that they are all accomplished through matter, directly or indirectly introduced to the spiritual part of man—the soul, which is as distinctly separate from the body, as a diver from his armor.

Knowing these facts, there never could be the shadow of a doubt with any sensible man that Sound is composed of infinitesimal particles of matter, the result of disturbance or shock, and demonstrated to be electrical.

The article on Anatomy in the Encyclopædia Britannica, 10th edition, in describing the ear, Vol. I., p. 893, says:

> "These auditory cells are therefore the peripheral end-organs of the vestibular branches of the auditory nerve, and their general arrangement is not unlike that of the olfactory nerves of the nose."

This statement of the anatomical conditions of the termination of the nerves of the two sensations, odor and Sound, by an anatomist deemed competent to expound this great subject for the Encyclopædia Britannica, would be alone almost conclusive that the sensations were of a similar character.

There is always room for corpuscles of sound equally with those of odor. And it is very evident that nature has made use of the same law for the accomplishment of all the sensations, as it might well be supposed that she would.

At one time it was claimed that odor was a mode of motion, which theory would undoubtedly have been adopted by modern text-books, had not the microscope made visible certain odoriferous particles.

Odor, too, is continuous, that is, it consists of a succession of particles, the sensation which it produces depending upon the number, as well as character of these particles. The same is true of Sound. It is true of all sensations, the most wonderful being light.

That anything which has to be duplicated by the million, each one of which must retain its exact form, until its mission is accomplished,—which frequently requires miles of travel through an atmosphere constantly changing, and often passing through other substances, as a door, or window, or wall, where it must go at different speed, if it is possible for it to go at all,—could be composed of a series of disconnected particles, is something that under any circumstances no person of good sense could believe, or would seriously consider.

The soul is the immortal part of man, the body being placed at its command, to enable it to acquire both knowledge and possessions. And all that the soul can learn of material things, it learns by the assistance of the body, through the five senses, touch, taste, odor, sound and light.

Touch is contact of the body with things, by which their presence becomes known. Touch always makes pressure and pressure makes motion, which, too, is a substance composed of infinitesimal particles of moving matter, whose mission is to convey, through the nerves to the soul, information of the touching bodies.

Taste comes from food introduced into the body, acting as a guide in the selection of food, and a necessary stimulus to its use. The sensation of odor is connected with the supplies necessary for the body, and also like taste agreeably affects the soul. There follow Sound and Light, both, as we have shown, especially designed for educational purposes, their function being entirely of this character, Sound having to do with language, and light with perception. The law of operation with all is the same, the introduction of matter into the body, by which the wants of the body and of the soul are equally provided for.

Thus also on the outside, by magnetism, a mixture of matter, are accomplished the signals by which man is able to give and receive information by telegraphy. In this case the result is obtained through a double use of matter—first magnetism, and second Sound.

VI.

THE following information in regard to Odor, we quote from "Ellen," Vol. II.:

"The senses are touch, taste, smell, hearing, and sight. We know that in order to experience the sense of touch there is and must be contact with a substance. It is impossible to obtain the result without this. And so in regard to taste; there is no taste possible unless there is something to be tasted.

"Next comes odor. And this is so pertinent to the subject that Ellen is discussing, that she will quote at length from an article on Odors, by the noted French scientist and writer, Ferdinand Papillon, as follows:

'Descartes, Leibnitz, and all the great minds of the seventeenth century, believed that phenomena are such interdependent parts of one whole, that they require to be explained by each other, and consequently, that a very close mutual connection should be maintained among the sciences. In their views, this was the condition of rapid advance and intelligent development. The experimental method, constant to systematic obstinacy in erecting so many barriers between the different sections of natural philosophy, has greatly hindered the completeness of whatever knowledge we possess as the result of mutual interaction among all truths. At this day, such barriers are tending to vanish of their own accord, and the science of man in his relations with external media begins to show the outlines of its plan and harmony. We have before this sketched several of its chapters, and we will endeavor now to write another, on the subject of odors.

'The seat of smell, or the olfactory sense, is the pituitary membrane lining the inner wall of the nostrils. It is a mucous surface, laid in irregular wrinkles, and receiving the spreading, slender, terminal filaments of a certain number of nerves. This membrane, like all other mucous ones, constantly secretes a fluid designed to lubricate it. By the aid of the muscles covering the lower part of the nostrils, the apparatus of smelling can be dilated or contracted, precisely like that of sight. This understood, the mechanism of olfaction is quite simple. It consists in the contact of odorous particles with the olfactory nerve. These particles are conveyed by the air to the inside of the nasal cavities, and there strike upon the sensitive fibres. If the access of air is prevented, or if the nerve is altered, no sensation is produced. Experiments in physiology, in fact, have settled that the olfactory nerves (or those of the first pair) are assigned exclusively to the perception of odors. Loss of the sense of smell occurs whenever the nerves are destroyed or injured by any process, or even whenever they are merely compressed.

'On the other hand, it is a matter of common observation that impeding the passage of air into the nostrils is quite as effectual a way of making any sort of olfactory sensation impossible. Let us add, that the region most sensitive to odors is that of the upper part of the nasal cavities. There are, as we shall notice in proceeding, considerable differences as regards the degree of sensitiveness in this sense of smell, comparing one man with another. But it is a still more singular fact that sometimes, without apparent cause, the sense is utterly wanting. In other cases it is unaffected by the action of certain odors only, an analogous infirmity to that which students of the eye call *daltonism*, and which consists in the perception of certain colors only. We find in scientific annals the case of a priest who was insensible to all odors except that of decayed cabbage; and another, of a person to whom vanilla was entirely without scent. Blumenbach speaks, too, of an Englishman, with all his senses very acute, who perceived no perfume in mignonette.

'Olfaction is sometimes voluntary, sometimes involuntary. In the former case, by an act which is called scenting something, and is resorted to for the sake of a keener sensation, we first close the mouth, and then sometimes draw in a full breath, sometimes a succession of short, quick inspirations. Then the muscular apparatus edging the opening of the nostrils comes into play, to contract that orifice, and point it downward, so as to increase the intensity of the current of inhaled air. When, on the contrary, we wish to smell as little as possible, the organ becomes passive. We effect strong expirations by the nose to drive out the air that produces scent, and inhalation, instead of being performed by the nostrils, instinctively takes place through the mouth.

'Scents and the sense of smell have an important share in the phenomena of gustation, that is, there is a close connection between the perception of odors and that of tastes. Physiological analysis has clearly brought out the fact that most of the tastes we perceive proceed from the combination of olfactory sensations with a small number of gustatory sensations. In reality, there are but four primitive and radical tastes—sweet, sour, salt, and bitter. A very simple experiment will convince us of this fact. If we keep the nostrils closed when tasting a certain number of sapid substances, so as to neutralize the sense of smell, the taste perceived is invariably reduced to one of the four simple savors we have just named. Then, whenever the pituitary membrane is out of order, the taste of food is no longer the same; the tongue distinguishes nothing but sweet, sour, salt, or bitter.

'It is time now to begin the study of the physiological and chemical conditions of smell, and for this we must first inquire how odorous substances behave with regard to the medium which separates them from our organs. Prévost, in an essay published in 1799 on the means of making emanations from odorous bodies perceptible to sight, was the first to bring to view the fact that certain odorous substances, solid or fluid, placed on moistened glass, or in a saucer full of water, instantly act on those molecules of the liquid which they touch, and repel them more or less, producing a vacuum. He judged that this method might serve to make odors sensible to sight, and enable us to distinguish odorous from inodorous bodies. These movements of odorous bodies on the surfaces of liquids, of which camphor particularly gives so curious an instance, have lately been studied with the greatest care by a French physiologist, with a view to establishing a theory of odors. With this purpose Liégeois has examined most of the odoriferous substances, and has ascertained that almost all of them perform various motions of circulation and displacement on the surface of water, resembling those noted with camphor. Some act precisely as camphor does. Among these are benzoic acid, succinic acid, the rind of bitter oranges, etc. With others, motion soon stops, for they are quickly surrounded by an oily film which keeps them confined. Some must be reduced to powder before the phenomenon takes place. As regards odorous liquids, it occurred to Liègeois to saturate very light and spongy seeds, themselves odorless, with them, and he then found, on throwing the seeds on water, that circulatory and displacing movements took place, as with other substances. He concluded, from a series of experiments methodically tried, that the motions in question must be attributed, not to a release of gas, acting in the manner of a recoil, but simply to the separation and rapid diffusion, within the water, of the odorous particles. The volatility of substances cannot be admitted to have any part in explaining the phenomenon. It depends wholly on the affinity of fluids for the odorous particles, and also for those of fatty matter. Liégeois found, for instance, that a drop of oil put on the surface of water, without sensibly lessening in size, emits an enormous quantity of microscopic droplets, which are diffused through the mass of the water.

Aromatic essences produce a like effect. Though insoluble in water, they have a powerful tendency to disperse themselves through it, and water that receives a very small quantity of the odoriferous principle, in the shape of extremely fine powder, has enough to gain their perfume completely. Liégeois's experiments give proof of the most diligent labors and of praiseworthy sagacity. Science has accepted them with satisfaction, and, after employing them usefully, will preserve the memory of their author, taken away in the flower of his age, at the outset of a noble career as a physiologist and surgeon.

'It seemed, to quote his words, as though in these experiments we were assisting at the formation of the odorous molecules. Those delicate atoms emitted from odorous substances and diffused through the atmosphere are, in fact, the very same that impinge on our pituitary membrane, and give us the sensation of odors. Moreover, facts long ago observed display this revealing action, so to call it, of water upon odors. At morning, when the verdure is moist and the flowers covered with sparkling pearls of dew, a fresher and balmier fragrance exhales from every plant. It is the same after a light shower. Vegetation gains heightened tints, at the same time that it diffuses more fragrant waves of perfume. We remark an effect of the same kind in the physiological phenomenon of taste. The saliva serves as an excellent vehicle for diffusing the odorous principles; then the movements of the tongue, spreading that fluid over the whole extent of the cavity of the mouth, and thus enlarging the evaporating surface, are clearly of a kind to aid the dispersion of the odorous principles, which, as we have seen, take a considerable part in the perception of tastes.

'Now in the phenomenon of smell, air acts in the place of water. It seizes the odorous particles and brings them into contact with the pituitary membrane. It is the vehicle, the solvent, of those extremely subtile atoms which, acting on the delicate fibres of the nerve, produce in it a special movement, which translates itself into the most varied sensations. Oxygen, and the existence in that gas of a certain proportion of odorous molecules, are the two essential conditions of this phenomenon.

'Such is, at least, the result of earlier experiments, and of those performed of late years by Nickles. A curious fact, well worthy of attention, is the remarkable diffusibility and degree of subdivision exhibited by some odorous substances. Ambergris just thrown up on the shore spreads a fragrance to a great distance, which guides the seekers after that precious substance. Springs of petroleum-oil are scented at a very considerable distance. Bartholin affirms that the odor of rosemary at sea renders the shores of Spain distinguishable long before they are in sight. So, too, every one knows that a single grain of musk perfumes a room for a whole year, without sensibly losing weight. Haller relates that he has kept paper for forty years perfumed by a grain of amber, and that they still retained the fragrance at the end of that time. He remarks that every inch of their surface had been impregnated by 1-2,691,064,000 of one grain of amber, and that they had perfumed for 11,600 days a film of air at least a foot in thickness. Evidently the material quantity of the odorous principle contained in a given volume of such air is so minute as to elude imagination.

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'Odors, to be perceived, must be taken up by oxygen, and borne by it to the organ of smell.

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'The learned and capable author, Piesse, in his work on "Odors, Perfumes, and Cosmetics," says: "Odors seem to affect the olfactory nerves in certain definite degrees, as sounds act on the auditory nerves. There is, so to speak, an octave of smells, as there is an octave of tones; some perfumes accord, like the notes of an instrument. Thus almond, vanilla, heliotrope, and clematis, harmonize perfectly each of them producing almost the same impression in a different degree. On the other hand, we have citron, lemon, orange peel, and verbena, forming a similarly associated octave of odors, in a higher key. The analogy is completed by those odors which we call half-scents, such as the rose, with rose-geranium for its semitone; 'petit-grain,' and neroli, followed by orange-flower. With the aid of flowers already known, by mixing them in fixed proportions, we can obtain the perfume of almost all flowers."

"Again Mr. Papillon says:

'To complete these details, it remains to say something of the delusion of the sense of smell; for this sense, like the others, has its aberrations and hallucinations. The delusions of smell are hardly ever isolated; they accompany those of hearing, sight, taste and touch, and are also less frequent than the latter.'

"And again:

'The intensity and delicacy of the sense of smell vary in mankind among different individuals, and particularly among different races of men. While some persons are almost devoid of the sense of smell, others, whose history is related in the annals of science, have displayed a refinement and range in the distinction of odors truly wonderful. Woodward, for instance, mentions a woman who foretold storms several hours before their coming, by the help of the sulphurous odor, due probably to ozone, which she perceived in the atmosphere. The scientific journals of the day relate the account of a young American girl, a deaf mute, who, by their odor alone recognized the plants of the fields which she collected. Numerous instances, moreover, prove that in savage races this sense is very greatly more developed than among civilized men.

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'But it is among the other mammals that we find the sense of smell displayed in its highest degree of power and perfection. Among ruminants, some pachyderms, and particularly among carnivorous mammals, the olfactory membrane attains the keenest sensitiveness. Buffon has described these animals with extreme exactness, in saying that they smell farther than they see, and that they possess in their scent an eye which sees objects not only where they are, but even wherever they have been. The peculiarity or scent in the dog is too well known to need more than allusion.

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'Alexander von Humboldt relates that in Peru, and other countries of South America, when it is intended to take condors, a horse or cow is killed, and that in a short time the smell of the dead animal attracts a great number of these birds, though none had before that been seen in the country. Other more extraordinary facts are told by travelers.

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'What, now, is the chemical nature of the odorous principles in plants? The chemistry of to-day reduces almost all of them to three categories of well-ascertained substances: hydrocarburets, aldehydes, and ethers. We will endeavor to give a clear account of the constitution of these three kinds of substances, and to mark their place in the register of science. The hydrocarburets are simple combinations of carbon and hydrogen, as, for instance, the petroleum-oils. They represent the simple compounds of organic chemistry. As to aldehydes and ethers, their composition is rather more complex; besides carbon and hydrogen, they contain oxygen. Every one knows what chemists mean by alcohol; it is a definite combination of hydrogen, carbon, and oxygen, neither acid nor alkaline, which may be regarded as the result of the union of a hydrocarburet with the elements of water. Common alcohol, or spirits of wine, is the type of the most important series of alcohols, that of the mono-atomic alcohols. Chemists represent it by the formula C^2H^6O, to indicate that a molecule of it arises from the union of two atoms of carbon with six atoms of hydrogen and one of oxygen. Independently of the alcohols, which are of great number and varying complexity, organic chemistry recognizes another class of bodies, of which vinegar is the type, and which receive the name of organic acids, to mark their resemblance to mineral acids, such as oil of vitriol or aqua fortis. Now every alcohol, on losing a certain amount of hydrogen, gives rise to a new body, which is called an aldehyde; and every alcohol, on combining with an acid, produces what is called an ether. These rapid details allow us to understand precisely the chemical character of the essences or essential oils which plants elaborate within their delicate tissue. Except a small number among them which contain sulphur, as the essences of the family of crucifers, they all present the same qualitative composition—carbon and hydrogen, with or without oxygen. Between one and another of them merely the proportion of these three composing elements varies, by regular gradations, but so as always to correspond either to a hydrocarburet, or to an aldehyde, or to an ether. In this case, as in almost the whole of organic chemistry, every thing is in the quantity of the composing elements. The quality is of so little importance to Nature, that *while following always the same laws and constantly using the same materials*, she can by merely changing the ponderable relations of the latter, produce, by myriads of various combinations, myriads of substances which have no resemblance to each other.

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'Such is the chemical nature of most of the odorous principles of vegetable origin. But chemistry has not stopped short with ascertaining the inmost composition of these substances: it has succeeded in reproducing quite a number of them artificially, and the compounds thus manufactured, wholly from elements, in laboratories, are absolutely identical with the products extracted from plants. * * * An Italian chemist, who was then employed in Paris in 1838, was the first who imitated by art a natural aromatic principle. By means of reactions suggested by theory, he prepared a salicilic aldehyde, which turned out to be the essence of meadow-sweet, so delicate and subtile in its odor. A few years later, in 1843, Cahours discovered methylsalicilic ether, and showed that it is identical with the essence of wintergreen. A year after, Wertheim composed essence of mustard, while believing himself to be making only allylsulphocyanic ether. * * * Nowadays the chemist possesses the means of creating many other natural essences. Common camphor, essence of bitter-Almonds, that of cummin and of cinnamon, which are aldehydes, as we have seen, may be prepared without camphor-leaves or almonds, without cummin or cinnamon. Besides these ethers and aldehydes whose identity with essences of vegetable origin has been proved, there exist, among the new bodies known to organic chemistry, a certain number of products formed by the union of common alcohol or amylic alcohol with different acids, that is to say, of ethers, which have aromatic odors more or less resembling those of some fruits, but as to which it cannot yet be affirmed that the odors are due to the same principles in both cases. However this may be, perfumers and confectioners, more industrious and wide-awake than chemists, have immediately made good use of these properties.. Artificial aromatic oils made their first appearance at the World's Fair of London in 1851. There was there exhibited a pear-oil, diffusing a pleasant smell like that of a jargonel, and employed to give an aroma to bonbons. This product is nothing else than a solution of amylacetic ether in alcohol. Apple-oil was exhibited beside the pear-oil, having the fragrance of the best rennets, and produced by dissolving amylvaleric ether in alcohol. The commonest essence was that of pineapple, which is nothing else than ordinary butyric ether. There was observed, too, an essence of cognac, or grape-oil, used to impart to poor brandies the highly-prized aroma of cognac. The product which was then and still is, the most important article of manufacture, is the essence of "mirbane," which very closely resembles in its odor that of bitter almonds, and which commerce very often substitutes for the latter. Essence of mirbane is nothing else than nitrobenzine, which results from the action of nitric acid on benzine.

Benzine in turn, is met with among the products of distillation of tar, which also yield the substances used in preparing those beautiful colors called aniline. Besides the essences we have just mentioned, which are gaining an increasing importance in the manufacturing arts, artificial essences of quinces are also prepared, and essences of strawberries, of rum, etc. All these preparations serve, it must be admitted, to give an aroma to the cordials, confectioneries, and sweetmeats, which are so largely sold nowadays. In other words, the products of industry are constantly taking the place of those of Nature more and more.' "

The gentleman who wrote this, recognized full well the necessity of considering nature's phenomena together, at least the great advantages to be gained by so doing, if we would understand them, and that this is especially true in regard to the more intricate ones.

Indeed there is no possible intelligent understanding of any of them, except as we do this. The Baconian system of experiment is unquestionably an excellent thing, if carefully made, and properly used. But nothing can take the place of good sense and capacity. Huxley well said:

> " No delusion is greater than the notion that method and industry can make up for lack of mother wit, either in science or in practical life; and it is strange that, with his knowledge of mankind, Bacon would have dreamed that he, or any other, 'via invendiendi scientias' would level men's wits and leave little scope for that inborn capacity which is called genius."

The laws governing the sensations of touch, taste, and odor, are readily discerned; and, in the case of odor, the materials of which they are made, so that they can be made equally well artificially. And it is clearly evident that the remaining sensations of hearing and sight, are accomplished in a similar manner. Indeed it doesn't require a very great amount of study and comprehension to perceive that the law governing them is a universal law of action between mind and matter; and though the mind's eye can not clearly discern where all of this leads, that is, the ultimate object or precise significance of such a system of interaction between mind and matter, it is able fully to perceive the essential nature of Sound and Light, particles of this thing, matter, and although so minute, as to be invisible to us, made by combination of different elements. We use this word element in its broad sense, one of the essential ingredients of any mixture.

The experiments made by Hauksbee, Priestley, and others, demonstrated that the intensity of sound depended upon the density of the air in which it was made, and therefore, Sound must be made in part at least, and perhaps entirely, the same as odor, from material existing in air.

"The experimental method constant to systematic obstinacy," has alone prevented the perception of this self-evident fact.

And it isn't the sensations only that are operated by these laws; the whole universe comes under this category. It consists in the interaction of mind and matter. That's all there is of it; at least, it is all that we have any suggestion of, unless it is their separate action, nor is it possible, intelligently, to consider matter as existing separate from mind.

"By the aid of the muscles covering the lower part of the nostrils, the apparatus of smelling can be dilated or protracted, precisely like that of sight. This understood, the mechanism of olfaction is quite simple. It consists with the contact of odorous particles with the olfactory nerve. These particles are conveyed by the air to the inside of the nasal cavities, and these strike upon the sensitive fibres."

And all of this is exactly what takes place with Sound, as well as Light. And what a magnificent method it is? Like all things else in nature, simple but complete. And it is very easy to see that there are no limits to its scope; there isn't any possible phenomenon, in the interaction of mind and matter, but what it might solve.

"Liègeois found that a drop of oil put on the surface of water, without sensibly lessening in size, emits an enormous quantity of microscopic droplets, which are diffused through the mass of water." * * *

"Those delicate atoms emitted from odorous substances and diffused through the atmosphere are in fact the very same that impinge on our pituitary membrane, and give us the sensation of odors. Moreover, facts long ago observed display this revealing action of water upon colors."

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"Every one knows that a single grain of musk perfumes a room for a whole year, without sensibly losing weight."

In an exactly similar manner Sound acts, spreading from a center in all directions, thus filling the atmosphere. And a sound from a small disturbance will fill the atmosphere for quite a space.

"Odors seem to affect the olfactory nerves as sounds act on auditory nerves. There is so to speak an octave of smells, as there is an octave of tones."

But perhaps the most remarkable feature in this chapter on odors, assisting in the explanation of Sound, is that which refers to their composition. For they, too, are very largely if not entirely manufactured in air, and wafted by air, or possibly by oxygen alone, to their destination.

It seems that they are composed of carbon and hydrogen; with or without oxygen. We suggest to every reader to re-peruse carefully the last three pages of this article of M. Papillon which refer especially to the essential nature of odors; for the great help of these discoveries in discovering the essential nature of Sound should not be overlooked. The moral of the whole is so plain that he who runs can read, that all the Sensations are made by the usual law in nature, the combination of matter.

VII.

THERE is introduced here another question that we have never seen discussed. By the corpuscular theory it is easy enough for the particles of Sound to pass through walls or windows, or get into copper, wood, iron, and a thousand other substances, more or less, the interstices being large enough to admit of their passage. But what is there to start the particles of iron, or other particles in the wall of a room, or a door, through which sound must go 14 times as fast as in air, for several inches, when, reaching the air of the next room, the remainder of the wave, or at least a part of it, will be composed again of air particles at the reduced rate? That is, this correlative of sound is moving in part at 15,314 (speed in ash) feet a second, and in part at 1040 (speed in air) feet; and should it be obliged to pass through several partitions as it might, its different parts would be constantly varying their speed, and of course would thus become entirely disconnected, and wholly unable by the theory to perform its supposed function.

We all know how easily sounds pass through partitions of buildings. To provide against this builders frequently insert substances which will deaden the sounds, especially between floors. The utter impossibility of so-called sonorous waves performing such a feat is evident to all, but this, as in all other phenomena of Sound, is precisely what infinitesimal particles of matter are fitted to do.

And therefore that Sound must consist of such particles we know from the nature of things, for thus only would it be possible for it to perform the functions for which it is made.

Thus odor consists, and of small size are grass and many other kinds of seed, the sands of the seashore, salt, sugar, dust. None of these could accomplish the things which they do, and in the same manner that they do, unless made as they are. If they did, the whole universe would have to be made over.

Sound pervades the atmosphere if uttered in it, entering every ear in any direction for a certain distance.

This distance depends upon the character of the sound, its life being proportional to its size or loudness, as also is the distance that it goes, for whatever its size, it goes at same speed, in same medium. And, as we have said, it circulates in many mediums, having within itself the power of motion.

It can be collected like grain in a hopper, as by an ear-trumpet, or the sail of a ship, or by a megaphone, or indeed any tube or anything fitted to hold it, as a tumbler, or vault, or room.

We quote from "Ellen," Vol. II., page 203-4, a very interesting and remarkable account of the sound of bells collected by the sail of a ship 100 miles from the source.

> "The widespread sail of a ship, rendered concave by a gentle breeze, is a good collector of sound. 'It happened,' says Dr. Arnott, 'once on board a ship sailing along the coast of Brazil, far out of sight of land, that the persons walking on deck, when passing a particular spot, always heard very distinctly the sound of bells, varying as in human rejoicings. All on board came to listen and were convinced; but the phenomenon was most mysterious. Months afterwards it was ascertained, that, at the time of observation, the bells

of the city of Salvador, on the Brazilian coast, had been ringing on the occasion of a festival; their sound, therefore, favored by a gentle wind, had traveled 100 miles by smooth water, and had been brought to a focus by the sail on the particular spot where it was listened to. It appears from this that a machine might be constituted having the same relation to sound that a telescope has to sight.' "

Sound will reverberate in many places and also, rebounding, make echoes.

It can be collected in a diafram and reflected from it, as heat,—which ' is evidently another substance composed of infinitesimal particles,—by a stove.

It can be carried in a wire or string, without electricity, for any short distance, and if the wire is insulated will be plainly heard for more than half a mile, which shows the sound to be electrical.

It can be carried in a wire by the electric current thousands of miles at the same rate the current goes (184,000 miles a second), and similarly as logs are carried down a river, at the same rate the river goes.

Ganot says:

> "The propagation of sound in solids is also well illustrated by the fact that in manufacturing telegraph wires the filing at any particular part can be heard at distances of miles by placing one end of the wire in the ear. The toy telephone also is based on this fact."

We quote again from "Ellen" Vol. II., page 497:

"And now Ellen will give another demonstration, that sound consists of infinitesimal particles of matter, and, in the telephone, is carried instantaneously through the wire by the electric current. And this is the action of the box telephone, which has been in use successfully to convey sound for over 250 years, perhaps in India and China for thousands.

"This consisted of two small boxes connected by a string or wire. At the bottom of each box, at the centre, was a membrane, or diafram, through the centre of which the string or wire passed and was fastened in the inside.

"The correspondence was carried on by a person at one end talking into the box, to a person at the other end holding the box to the ear, the same boxes answering for sending or receiving instrument. The sound went through the string or wire.

"Practically the operation is precisely similar to the modern telephone, except the electric current and magnet are wanting. Because they were wanting, the use of the box telephone was limited, as the sound couldn't go fast enough through the string or wire to last for a very long distance.

"This proves that sound under such conditions enters a wire or string, and passes along or through it, until its force is expended, which last is a mere question of time. It also proves that sound, with such conditions, will get out at the other end of the line, or anywhere else if given opportunity, and enter the listener's ear.

"It follows that it must do the same in the modern telephone, where just as in the air to the speed of sound must be added the speed of the wind, there must be added here the speed of the electric current. And therefore, and for no other reason, the distance of its journey is immensely increased.

"And this is a demonstration that the sound heard at the telephone is that which enters the sending instrument."

"And will not Ellen repeat," I asked, "this demonstration?"

"The demonstration is," she replied, "that sound, articulate speech or otherwise, does get into a wire and run along through it, always, when an arrangement like that of a telephone transmitter exists. And therefore it must get into the wire of a telephone and be carried instantaneously, until it finds opportunity to get out—which always exists at end of line, and may take place in many places along the line—unless it is destroyed by the current, and we know it is not destroyed but goes through. There could hardly be any better practical demonstration."

In same Volume, pages 534—539, is an article entitled, "On the Transmission of Vocal and other Sounds by Wires," by W. J. Millar in Philosophical Magazine, from which we quote:

OBJECT OF PAPER.

'1. The object of the present paper is the description of a series of experiments made by the author upon the transmission of vocal and other sounds by wires, and the results obtained from these experiments.

'2. TRANSMISSION OF SOUND IN GENERAL.—The transmission of sound by various media is familiarly illustrated from day to day; and the readiness with which these media are affected has been made the subject of many experiments.

'One familiar illustration of the transmission of sound from air to solids and thence back to the air is that which occurs in the vertical and horizontal partitions between rooms, such as partition walls and floor and ceiling spaces—the sounds originating in one room being thus transmitted to the adjoining room without having recourse directly to air communication.

'From a consideration of the latter, as also from other phenomena, the author has for some time been convinced that vocal sounds might be transmitted by solid bodies, such as wires, and that to considerable distances.

'After several unsuccessful attempts, the author during the month of January last, having occasion to use some fine copper wire, carried a portion of it out from the house to a distance of about 20 yards, and attached a couple of pasteboard disks with low rims to the ends of the wire: the transmission of vocal sounds was then found to be easily effected, conversation being readily carried on through this length of wire.

NOTES OF OTHER IMPORTANT EXPERIMENTS.

'(1). No. 23 copper wire was stretched between windows outside of a house and attachments at right angles made to rooms through the windows. Speaking in one room was then heard in the other, the distance was about 20 yards. Pianoforte music was easily transmitted by placing an ear-piece inside the instrument and carrying the other end of the wire outside the house.

'(2). No. 40 copper wire fitted up in a building passing from room to room. Six attachments and angles.

'Distance about 50 yards. Conversation, singing, whistling, breathing, and the sound of a light C tuning-fork (2¼ inches in fork) readily transmitted.

'Various similar arrangements were also made in house from room to room, and finally carried to a distance outside, where all the above effects, as also the transmission of whispering, were clearly demonstrated, the person at either end being quite out of hearing in the ordinary manner.

'*The communication was not limited to the persons at either end of the wire; additional connections were occasionally made, where three or more individuals could communicate with each other.*

'(3). Carried about 7 yards of No. 23 copper wire from one room through an adjoining one to a room beyond, the wire in its course passing below two doors shut above it, and for the most part in contact with the carpet, but fastened at the ends so as to produce some tension. Made two connections of No. 40 copper wire at angles with the main wire; conversation was then readily carried on and all the phenomena already described produced. Subsequent experiments with No. 16 copper wire arranged as above were found to yield better results.

'A somewhat similar and equally successful experiment was made by carrying the same size of wire down stairs, passing below two doors and partly resting on carpet and wood. A positive advantage is gained by resting the heavy wire in this manner, the words being clearer and more distinct, and free from the rumbling sound occurring with a suspended wire free to move about.

'(4). Fastened No. 23 copper wire to telegraph wire, made another and similar attachment 75 yards further on, but within two posts. Breathing, whistling, and tuning-fork sounds readily transmitted.

'(5). Carried the latter attachment to 150 yards, thus passing one post. Breathing, whistling, singing, and the sound of the light C tuning-fork, formerly mentioned readily transmitted. No apparent loss though passing the support (the latter was of the usual china-ware cup with binding-wire). The speaking was not so distinct, although the different word-sounds were discernible. This can be accounted for by the fact that, as the poles were about 14 feet high, the attachment ends were free to swing about, which, combined with the exposed situation of the main line, gave rise to a considerable vibratory action due to other causes than the vocal sounds.

'4. THE MOUTH AND EAR PIECES.—The mouth and ear pieces used in these experiments have been of various materials and forms. The materials tried have been pasteboard, wood, gutta-percha, india-rubber, parchment, iron, tin, and zinc. These have been generally arranged as discs or drums, having a more or less extended rim around them to confine the sounds. This rim has been of cylindrical, conical, and other forms.

'In general, greater volume of sound accompanied increased depth of rim; but the sounds were hardly so distinct as when the rim was kept shallow.

'The wire was usually attached to the centre of disc; but in some cases good results were got where the wire was led through a cylindrical hollow piece of wood and terminated close to the disc; indeed a hollow piece of wood without a disc did very well.

'As a rule, the effects seemed better where the wire was led outside of the house.

'High-pitched voices are more easily heard than deep strong voices.

'In the experiments with the telegraph wire one of the discs used was of thin sheet iron 3½ inches in diameter. Set in a wooden rim about ½ inch deep, the wire was fastened into a small piece of wood, which in turn was cemented down to centre of disc. The tuning-fork sounds were very well heard with this arrangement; and one peculiarity was that, on the wooden fastening accidentally breaking away from the iron, the sounds could again be heard by holding the disc in one hand and pressing the wooden termination of the wire upon the disc with the other.

'WIRES.—The wires, as a rule, require to be more or less tightened up; but this varies with the heaviness of the wire.

'The sound is increased with a tight wire.

'The volume of sound appears to be increased with a heavy wire. Thus in the telegraph wire about one-eighth inch thick, probably No. 8, the sounds were stronger and fuller than in the thinner wires, and, probably owing to the high tension of the former, faint sounds were more readily transmitted: thus the accidental or intentional touching of the tuning-fork with the rim of the mouth-piece, causing a slight clicking sound, was distinctly heard through the ear-piece at a distance of 150 yards — and this, even although the two attachments of copper wire were practically at right angles to the main wire, whereby part of the sound would pass away onwards up and down the line.

'6. The delicacy of the action may be inferred from the fact that fine sand strewn upon the disc of the ear-piece is unaffected by conversation through lengths of about seven yards. The sensitiveness also of the mouth-piece was shown by sounds not spoken into it being readily transmitted, such as coughing, laughing, or remarks made by persons standing beside the instrument. Indeed, in some cases an advantage is obtained by keeping back from the mouth or ear-piece: and the author has sometimes thought an improvement was obtained by holding the ear-piece slightly inclined to the ear.

'In all cases the individual voice could easily be distinguished, though modified more or less by the structure and material of the mouth and ear-piece.

'The mouth and ear-pieces were usually of the same form and material, and were therefore used for either speaking or hearing. Some forms, however, do better as ear-pieces, other as mouth-pieces.

'In conclusion, the author believes that many interesting physical questions may be studied by means of these arrangements, and that practical application may be made where communication of this nature is required.'

And again pages 623, 615, of "Ellen":

"'Another very interesting experiment by M. A. Brèguet shows that all the constituent parts of the telephone—the handle, the copper rims, and the case, as well as the diafram and the electro-magnet—can transmit sounds. M. Brèguet ascertained this fact by the use of string telephones, which he attached to different parts of the telephone on which the experiment was made. In this way he was not only able to establish a correspondence between the person who worked the electric telephone and the one who was listening through the string telephone, but he also made several string telephones act, which were attached to different parts of the electric telephone.'"

"'Messrs. Heaviside and Nixon, in their experiments at Newcastle-on-Tyne, have ascertained that the most effective wire was No. 4 of the English gauge. They employed wooden disks an eighth of an inch in thickness, and these may be placed in any part of the length of the wire. When the wire was well stretched and motionless, it was possible to hear what was said at a distance of 690 feet, and it seems that Mr. Huntley, by using very thin iron diaframs, and by insulating the line on glass supports, was able to transmit speech for 2450 feet, in spite of the ziz-zags made by the line on its supports.'"

In other words Sound went through the wire and was heard over three times as far when the wire was insulated, which sustains in the strongest possible manner Oersted and Ritter's statements that Sound was electrical.

Sir J. F. W. Herschel in the Encyclopædia Metropolitana says:

"Chladni relates an experiment made by Messrs. Herhold and Rofn in Denmark, where a metalic wire 600 feet long was stretched horizontally. At one end a plate of sonorous metal was suspended and slightly struck; an auditor placed at the other, and holding the wire in his teeth, heard at every blow two distinct sounds; the first transmitted almost instantaneously by the metal, the other arriving later through the air."

Pulses of air, fraudulently called sound waves, could accomplish no one of these things. There is not indeed a single phenomenon of Sound that can be explained by the undulatory theory. On the other hand there is no known phenomenon of Sound which cannot be intelligently and fully explained by the corpuscular theory.

The great English scientist Huxley, in referring to hypotheses, said:

"Every hypothesis is bound to explain, or at any rate not to be inconsistent with, the whole of the facts it professes to account for; and if there is a single one of these facts which can be shown to be inconsistent with (I do not merely mean inexplicable by, but contrary to) the hypothesis, such hypothesis falls to the ground—it is worth nothing. One fact with which it is positively inconsistent is worth as much, and is as powerful in negativing the hypothesis, as five hundred."

And Faraday, equally renowned, truthfully says:

"But it is always safe and philosophic to distinguish, as much as in our power, fact from theory; the experience of past ages is sufficient to show us the wisdom of such a course; and considering the constant tendency of the mind to rest on an assumption, and when it answers every present purpose, to forget that it, in such cases, becomes a prejudice, and inevitably interferes, more or less, with a clear sighted judgment, I cannot doubt but that he, who, as a wise philosopher, has most power of penetrating the secrets of nature, and guessing by hypotheses at her mode of working, will also be most careful, for his own safe progress and that of others, to distinguish that which consists of assumption, by which I mean theory and hypothesis, from that which is the knowledge of facts and laws; never raising the former to the dignity or authority of the latter, nor confusing the latter more than is inevitable with the former."

VIII.

AS translated in 15th edition, Ganot says:

> "Sound is always the result of rapid oscillations imparted to the molecules of elastic bodies, when the state of equilibrium of these bodies has been disturbed either by shock or by friction. Such bodies tend to retain their first position of equilibrium, but only reach it after performing, on each side of that position, very rapid vibratory movements, the amplitude of which quickly decreases."

We deny that there are oscillations of molecules of elastic bodies, whose state of equilibrium was disturbed by shock, and demand the proof. This whole statement, and everything that depends upon it, is arrant nonsense. If Mr. Ganot, or scientists who accept and teach this, cannot prove it, they have no right to say it. It's an hypothesis and never was anything more, and we have given proof that nothing of this kind occurs, but instead that Sound, which is particles of electrical matter produced by shock, causes the vibration of the fork.

Mr. Ganot further says:

> "The conductibility of solids is such that the faint scratching of a pen or the ticking of a watch at one end of a long horizontal wooden rod is heard much more distinctly when the ear is directly applied against the other end of the rod than when it is at the same distance in the air. Sound may even reach the ear through solids alone without passing through the air; for if the ears are closed, and the rod be put between the teeth, the ticking is distinctly heard. The earth conducts sound so well that at night, when the ear is applied to the ground, the stepping of horses, or any other noise at a distance, is heard."

It will be seen from the above that many things are a much better conductor of Sound than air, but not so convenient for the purposes of man. It would of course be impossible for particles of solid substances to be moved by particles of air hitting them, as they would have to be repeatedly, under the most extraordinary circumstances, if this undulatory theory was true.

Thus one may be in the centre of a large room, with wooden partition surrounding it, and holloo or speak so as to be readily heard outside for some distance, but as in wood, as we have seen, sound goes much faster than in air, and in ash wood over 14 times as fast, if it was possible for these hypothetical sound waves to take place in ash, all representing ordinary words would have to be from 28 to 988 feet in length. In the supposed instance of passing from the medium of air to that of ash, they would have to be started by so called air waves of $\frac{1}{14}$ the length and $\frac{1}{14}$ the swiftness, and, supposing the partition two inches, instantly change back into air waves of condensation and rarefaction $\frac{1}{14}$ the length and speed. The whole conception is so appalling, violating all laws of nature, or common sense, in such an idiotic way, that we desist from following it up further, and respectfully request scientists who believe in this theory, if there really are any who do, to explain how sound is thus conveyed from one medium into another.

Accepting the corpuscular theory, the explanation is very simple. The particles of Sound go through a partition when, and only when, there are insterstices large enough for them to do it. We might, too, have half-a-dozen partitions of different substances, through all which Sound goes with different speed, and into none of which could particles of air enter, but through which readily a loud call could be heard.

And this inconceivable sound wave is seriously proposed as the correlative of Sound. That is, the wave in its form must represent all the characteristics of sound, not only the pitch and intensity, but also the *clang tint* or color, including every intonation of the voice, and any possible variation of tone. This is what these waves mean, if they mean anything. There would be no undulatory theory if they did not do this. And if they should be at all disturbed, the part affected would be shattered like a torn leaf, or entirely wanting to the hearer.

But we have seen how easily all the difficulties of the undulatory theory are explained by the corpuscular. And these corpuscles evidently consist of, or resolve themselves into millions or billions of particles; those made by the same sound always exactly alike; in this respect similar to the corpuscles of odor, which are always alike, when made by the same or a similar odoriferous body.

Such particles as these it is that, spreading like mist, fill the atmosphere with Sound; short lived and moving rapidly, but abundantly sufficient to perform the wonderful mission that God created them to do. How well they do it those may realize best who have lost the sensation of sight. For all known knowledge of the universe may be taught to every human being through the sensation of Sound alone. It is, too, very useful to beings of a lower order than man. Simple are the laws of nature, always the simplest possible. In that way does she accomplish so much and accomplish it so well.

Referring to the intensity of Sound, Mr. Ganot says:

"Many causes modify the force or the *intensity* of sound. These are the distance of the sounding body, the amplitude of the vibration, the density of the air at the place where the sound is produced, the direction of the currents of air, and lastly, the neighbourhood of other sounding bodies. *The intensity of sound is inversely as the square of the distance of the sounding body from the ear.*

"The distance at which sounds can be heard depends on their intensity. The report of a volcano at St. Vincent was heard at Demerara, 300 miles off, and the firing at Waterloo was heard at Dover.

"*The intensity of sound increases with the amplitude of the vibrations of the sonorous body.* The connection between the intensity of the sound and the amplitude of the vibrations is readily observed by means of vibrating strings. For, if the strings are somewhat long, the oscillations are perceptible to the eye, and it is seen that the sound is feebler in proportion as the amplitude of the oscillations decreases. The intensity varies as the square of the amplitude of oscillation.

"*The intensity of sound depends on the density of the air in the place in which it is produced.* As we have already seen when an alarum by clock-work is placed under the bell jar of an air-pump the sound becomes weaker in proportion as the air is rarefied.

"In hydrogen, which is about $\frac{1}{14}$ the density of air, sounds are much feebler, although the pressure is the same. In carbonic acid on the contrary, whose density is 1.529, sounds are more intense. On high mountains where the air is much rarefied, it is necessary to speak with some effort in order to be heard, and the discharge of a gun produces only a feeble sound. The ticking of a watch is heard in water at a distance of 23 feet, in oil of 16½, in alcohol 13, and in air of only 10 feet.

"*The intensity of sound is modified by the motion of the atmosphere* *and the direction of the wind.* In calm weather sound is always better propagated than when there is wind; in the latter case, for an equal distance, sound is more intense in the direction of the wind than in the contrary direction.

"Lastly, *sound is strengthened by the neighbourhood of a sonorous body.* A string made to vibrate in free air has but a feeble sound; but when it vibrates above a sounding-box, as in the case of a violin, guitar, or violoncello, its sound is much stronger. This arises from the fact that the box and the air which it contains vibrate in unison with the string. Hence the use of *sounding-boxes* in stringed instruments."

In any correct use of language the amplitude of the vibration does not modify the intensity of Sound. It is modified by it.

One might as well say that a shadow modified the size of the body which makes it. Or that anything modifies the thing that produces it. This is putting the cart before the horse.

The intensity of Sound is its loudness, and depends upon the amount of Sound, and that depends upon the amount of the disturbance which makes it, and, as in everything else, the amount of material at command, from which it can be made—following a universal principle in nature that effects are proportional to amounts.

Sound to be electrical must be composed in part of electricity, just as anything that is salt must be composed in part of salt, or that is sweet, in part of the principle of sweetness, as before mentioned; for that is what salt and sweetness are for—to make things salt and sweet; nor is nature known to make superfluous causes. The other parts of the combination might be drawn from air, as indeed this part might, but wherever the material of which it is made is obtained, Sound is created by shock or friction, and is admirably designed to produce the sensation of hearing.

Thus, too, by friction, electricity, one of the most useful and powerful agents, is created instantly, and from materials we cannot see.

Sound perishes rapidly; but it is also manufactured with wonderful facility. In air Sound moves equally in all directions, and therefore its intensity is inversely as the square of the distance from the sounding body. The vibration of bodies is made by the sound and is therefore proportional to the sound.

Ganot says:

> "The following experiment shows that the presence of a ponderable medium is necessary for the propagation of sound. A small metal bell, which is continually struck by a small hammer by means of clockwork, or else a musical box, is placed under the receiver of an air-pump. So long as the receiver is full of air at the ordinary pressure the sound is transmitted; but in proportion as the air is exhausted the sound becomes feebler, and cannot be heard in a vacuum.
>
> "To insure the success of the experiment, the bellwork or the musical box must be placed on wadding or on a block of vulcanised rubber; for otherwise the sound would be transmitted to the air through the plate of the pump.
>
> "If, in the above experiment, any vapour or gas be admitted after the vacuum has been made, the sound of the bell will be heard, showing that sound is propagated in this medium as in air.
>
> "Sound is also propagated in liquids. When two stones are struck against each other under water, the shock is distinctly heard; and a diver at the bottom of the water can hear the sound of voices on the bank. The sound is, however, enfeebled, as a considerable portion is reflected at the boundary of the two media."

If the second paragraph is true, then the trouble would appear to be want of a proper medium to convey the sounds. But is it true?

The article on Acoustics, in the Encyclopædia Britannica, says:

> "De Saussure, the celebrated Alpine traveler, mentions that the report of a pistol at a great elevation appeared no louder than would a smaller cracker at a lower level.
>
> But it is to be remarked that, according to Poisson, when air-strata of different densities are interposed between the source of sound and the ear placed at a given distance, the intensity depends only on the density of the source itself; whence it follows that sounds proceeding from the surface of the earth may be heard at equal distances as distinctly by a person in a floating balloon as by one situated on its surface; whereas any noise originating in the balloon would be heard at the surface as faintly as if the ear was placed in the rarefied air on a level with a balloon. This was exemplified during a balloon ascent by Glaisher and Coxwell, who, when at an elevation of 20,000 feet, heard with great distinctness the whistle of a locomotive passing beneath them."

It is difficult to accept both of these statements. It does not in either case affect the principle that Sound is corpuscular, but the last statement would appear to directly oppose the first.

VIII.

THE first recorded experiments of the action of Sound in a vacuum were made by Francis Hauksbee and appear in Philosophical Transactions, Vol. V. (1703–1712), pp. 202, 203 and 499, 500, as follows:

FROM PHILOSOPHICAL TRANSACTIONS.

An Experiment made at a meeting of the Royal Society, on the Diminution of Sound in rarefied Air. By Mr. F. Hauksbee:

"A bell being included under a receiver, which being shaken to make the clapper strike, it was very observable that the interposition of the glass between the bell and the ear, was a great obstruction to its sound, yet it was audible at some good distance from it: but gradually withdrawing the air, and making several stops to shake the bell at different degrees of rarefaction, the diminution of the sound at every stop was being distinguishable. Till at last, when the receiver was well exhausted of air, the remains of sound was there so little, that the best ears could but just distinguish it: it appearing to them like a small shrill sound as at a great distance. On suffering the air gradually to re-enter, it was easy to perceive the increase of sound at the different times the bell was made to ring: the recipient being again replete with air, the sound then seemed something more clear and audible than at its first inclusion."

An Experiment made at Gresham College on the Propagation of Sound in condensed Air. By Mr. F. Hauksbee, Vol. XXIV., p. 202, 203:

"A bell being included in a trap recipient, and placed at one end of a room about 50 yards long, at the other end of which stood some gentlemen to observe the sound; before any air was intruded the bell on shaking was heard at that distance, although not without diligent attention. On the intrusion of one atmosphere of air, the bell being shaken as before, the sound was very sensibly augmented; two atmospheres being impelled and the bell made to ring, a considerable improvement of the sound was then manifest. But on the intrusion of the third, fourth and fifth atmosphere, the bells being made to strike, the sound seemed not to be propagated proportionably to the first and second; which might happen by means of some escape of air, or the valve, which should have hindered the return of the injected air, not holding so tight as it ought; but that some of the intruded air would repass into the syphon, by which means the quantities supposed injected were deficient. Another reason why the latter atmospheres did not propagate the sound as the two first, is this; though 25 compressions of the syphon are equal to the natural content of the recipient, yet when the air becomes pretty strongly condensed, as by the intrusion of 4 or 5 atmospheres, the remaining air at every stroke, which will lie between the bottom of the embolus and the valve (though but little) is at the same density at the same time as the air in the recipient; which, on drawing up the forcer, will extend itself, to supply such a space of the cylinder as so much common air; and is so much short of what should be injected at every stroke, 25 of which become equal to the natural content of the receiver. Hence the deficiencies of the real atmospheres, or quantities, by a certain number of strokes, may be very considerable, and to account for them, very difficult.

"Notwithstanding the deficiencies are not known, yet at the end of the 5 (though imperfect) atmospheres, the bell being shaken as at first, it was the opinion of a gentleman then 50 yards distant that the sound seemed to be almost as sensible as when it came to be made and exposed in the open air.

"June the 9th about five in the morning I repeated the experiment in an open field, called the White Contrast, with much the same success as the former. On shaking the bell before any air was intruded, it was just audible at 30 yards distant. On the injection of one atmosphere it became then as audible at 60 yards as it was before at 30. A second being introduced, the bell on shaking might then be heard at 90 yards distance. But after that though near 100 strokes of the forcer were repeated, yet could it hardly be heard 20 yards further, which I attribute in a great measure to the reasons before given."

This last experiment would appear to demonstrate that the intensity of Sound depends upon the density of the air where it is made. Similar experiments are reported by the noted English chemist Mr. Priestley, with same results, and, so far as we have seen, all text-books and encyclopædia articles on Sound admit this principle. If true as stated it would appear that sound is composed in part at least from material obtained in air; which of course is alone a demonstration that sound is corpuscular.

An Experiment, showing that actual Sound cannot be transmitted through a Vacuum. By Mr. Fr. Hauksbee, F.R.S. N° 321, p. 367 [1703 to 1712].

"That the experiments already made, endeavouring to produce from a bell in vacuo, have been altogether ineffectual, is well known. Yet that the loss of it should be wholly attributed to the absence of the air, I think could not without another experiment be absolutely concluded, since the following query might fairly be started on this occasion; viz. whether the sonorous body in such a medium might not so suffer, or undergo such a change in its parts, as to be rendered incapable of being put into such a motion as is requisite for the action or production of sound. Now to bring this to the test, I contrived the following experiment.

"I took a strong receiver, armed with a brass-hoop at bottom, in which I included a bell as large as it could well contain. This receiver being screwed strongly down to a brass-plate, with a wet leather between, was full of common air, which could in no way escape. Thus secured, it was set on the pump, where it was covered with another large receiver. In this manner, the air contained between the outer and inner receivers was exhausted. Now here I was sure, when the clapper should be made to strike the bell, there would be actual sound produced in the inner receiver, the air in which was of the same density with common air, and could suffer no alteration by the vacuum on its outside, being so strongly secured on all sides. Thus all being ready for trial, the clapper was made to strike the bell; but there was no transmission of it through the vacuum, though it was certain there was actual sound produced in the receiver. This plainly shows, and seems positively to confirm, that air is only for the propagation of sound."

An Experiment showing the Propagation of Sound passing from the Sonorous Body into the common Air, in one Direction only. By Mr. Fr. Hauksbee, F.R.S. N° 321, p. 369.

"Since, by the former experiment, actual sound could not be transmitted through a space void of air; I was inclined to try whether a sound, propagated in a receiver, having a communication with the open air at one small aperture only, but otherwise entirely surrounded by a vacuum, would be increased, or continued sounding longer, at each stroke given the bell, than it would do, were its body encompassed by such a medium. I therefore included the bell as in the foregoing experiment; only, to the upper part of its receiver, was screwed a box with collars of leather; and on the top of the outward receiver, was laid a brass-plate with a wet leather between; in the middle of which plate, was likewise screwed another brass box with collars, as before. These receivers, when placed on the pump, had their boxes standing directly one over the other. Through both of them in that position, I passed a hollow brass tube, which exactly fitted their perforations: thus the inner receiver had a communication with the outward air, and the outer rçceiver was thereby secured from the ingress of the circumambient medium. Now when the air contained between the receivers was pretty well exhausted, and the bell struck, the sound was sensibly very vigorous, and very nearly as great as before any air was exhausted; yet if a finger was applied to the aperture of the hollow brass tube, the sound would be so much diminished, as but just to be distinguished. By this we see, that since the sound in that state cannot be transmitted through the receiver that includes it, by means of the surrounding vacuum, yet the receiver is certainly struck with it; but finding no conveyance that way, reverberates and makes its passage where it finds least resistance. Nor did I observe, that though the sound had but one passage from its receiver, and that but a small one, that it continued any longer after the stroke, than if it had been made in the open air."

An Experiment on the Propagation of Sound through Water. By Mr. Fr. Hauksbee, F. R. S. N° 321, p. 371.

"As a former experiment showed that sound could not be transmitted through a vacuum, I was induced to try what would be the effect, by surrounding the receiver, that contained the sounding body, with so dense a medium as water. Accordingly, as in the former experiment, the receiver which contained the bell was screwed down to a brass-plate, with a leather between; this receiver with its bell, was suspended in a large glass vessel, by four threads to the top, and as many to the bottom, by which it remained in the middle between both. Thus provided, the clapper was made to strike the bell, whose sound was somewhat less by the interposition of the glass than it would be when made in the open air; however it was very audible, and might be heard at a considerable distance; it appeared to the ear to be very harsh, in respect to the tone it yielded. But now, when the water came to be poured in, and the inner receiver surrounded by it, at least an inch and a half from the nearest part of the outer glass, the clapper again was made to give the sound; which it did, seemingly very little less in respect of its audibility, but much more mellow, sweet, and grave, at least two or three notes deeper than it was before."

IX.

THESE experiments, all considered, show that Sound must have a sufficiently dense medium to move in. It apparently cannot advance in a so-called vacuum, neither could a bird fly. It would appear, from experiments as reported, by a number of reliable physicists, and accepted by all, that the intensity of Sound depends upon the density of the air where it is made. But if so it must be made in part at least, from air, or substances in air.

Mr. Hauksbee was a very careful experimenter but both he and Dr. Priestly entirely failed to estimate correctly the possible meaning of the experiments. Mr. Hauksbee says:

> "This plainly shows, and seems positively to confirm, that air is the only medium for the propagation of sound."

What it might show was that Sound couldn't be conveyed through a vacuum, future discoveries proving that it could be conveyed by a thousand different mediums more or less, besides air.

A little later Mr. Hauksbee demonstrated it could be conveyed through water. Neither here nor in the air is there any disturbance perceptible. The only place there is, is in the sounding body and certain bodies that conduct Sound. And here again the scientists, at least most of them, have blundered in supposing or assuming that the agitation of the sounding body was caused by particles being a part of it, making these sensible oscillations without being able themselves to separate.

And such an absurd supposition or hypothesis, although the movement always follows a blow, which might create any possible force—and also, although demonstrated by vibrating plates, that infinitesimal particles of matter or corpuscles make a veritable movement at different portions of the vibrating body, passing between nodes; whilst in addition to this is the striking fact, that the sound made in musical bodies by shock is always conducted through the air in all directions in which the air extends, with distances depending upon the intensity of the sound.

Also these sounds may be conducted by different bodies indefinite distances, flowing like a stream, or in some respects like electricity; though their flow is far more rapid than ordinary streams, and not near so fast as the electrical current.

This, too, is noticeable in the movement of Sound, that you can trace or conduct it. Trace it, because through many mediums it produces a trembling motion, from the time it leaves the musical instrument in which it is made until its force is spent.

For instance such sound flows from a tuning-fork when its stem is placed upon a proper medium. Nobody can suppose that it is particles of the fork that thus flow. Everyone knows, or can know by proper observation, that it is Sound, made by shock, and consisting of infinitesimal particles of electrical matter, which carry within themselves the power of movement at all grades.

On page 218, Mr. Ganot refers to a peculiar phenomenon of sound, called Doppler's principle, as follows:

"When a sounding body approaches the ear, the noise perceived is some what higher than the true one; but if the source of sound recedes from the ear, the note perceived is lower. The truth of this, which is known as *Doppler's principle*, will be apparent from the following considerations:—When the source of sound and the ear are relatively at rest, the ear receives *n* waves in a second; but if the ear approaches the sound, or the sound approaches the ear, it receives more; just as a ship meets more waves when it ploughs through them than if it is at rest. Conversely, the ear receives a smaller number when it recedes from the source of sound. The effect in the first case is as if the sounding body emitted more vibrations in a second than it really does, and in the second case fewer. Hence in the first case the note appears higher; in the second case lower.

"To test Doppler's theory Buys Ballot stationed trumpeters on the Utrecht railway and also locomotives, and had the height of the approaching or receding notes compared with stationary ones by musicians. He thus found both the principle and the formula fully confirmed. Similar conclusive experiments were made by Scott Russell on English railways. The observation may often be made as a fast train passes a station in which an electric alarum is sounding. Independently of the difference in loudness, an attentive ear can detect a difference in pitch on approaching and on leaving the station. A speed of about 40 miles an hour sharpens the note of the whistle of an approaching train by a semitone, and flattens it to that extent as the train recedes.

"Doppler's principle may also be established by direct laboratory experiments. Rollmann fixed a long rod on a turning table, at the end of which was a large glass bulb with a slit in it, which sounded like a humming-top when a tangential current of air was blown against the slit. The uniform and sufficiently rapid rotation of the sphere developed such a current, and produced a steady note, the pitch of which was higher or lower in each rotation according as the bulb came nearer, or receded from, the observer.

"The principle may also be illustrated by means of a tuning-fork with wide branches, and producing a very high note of 2,046 vibrations. When this is loudly sounded, and, being held in front of a smooth wall, is moved towards it with a velocity of a metre in a second, the direct note and that reflected from the wall undergo opposite changes, so that an observer hears distinctly twelve beats in a second."

Wanted, the amount of sound from a distant stationary engine, heard in a given time by a person standing still; also when the engine approaches the person, or the person the engine, or both. Let us suppose the distance, a quarter of a mile between the engine and listener, each stationary. We will suppose, that the engine when whistling makes 60 shocks a minute, and each shock a vibration. We will suppose, too, that it will take one second for the sound to reach the listener. In one minute, then, 60 shocks or vibrations of Sound would be made by the stationary engine, and all would reach the listener in that time, but no time to spare. It would all, too, be of the same intensity, because coming the same distance.

Let us now suppose that the engine approaches the listener, making the distance in one minute. The sound reaching the listener would constantly increase in intensity, because constantly having less distance to go; but the intensity or loudness of sound, does not affect its tone.

We have assumed that the engine will make 60 shocks in one minute as it approaches the listener. The sound arising from these would be heard in 59 seconds, one second being taken up with the passage of the sound from the engine to the listener. And thus in addition to the usual amount of sound heard in a given time when listener and engine are both stationary, the hearer, would receive as much additional sound as is made in one second and, if the speed of the moving engine was constant, this would be distributed equally throughout the time.

But, as a matter of fact, the whistle would make a great many more vibrations a second than supposed, and all, whatever their number, would be received by the listener, in addition to what he would receive if the engine remained stationary. And thus it would appear that the tone depends upon the number of vibrations, made by the same instrument, received in a given time by the hearer, being higher with increased number, and lower with decreased. That is, the Doppler experiment adds to the proof that tone, other things being equal, depends upon the rapidity of the vibrations. But the vibrations depend upon the character or nature of the body which vibrates, and also the force, infinitesimal particles of electrical matter made by shock, which makes it vibrate.

The same results would take place if the engine and hearer both approached each other; and directly the opposite if separating. This again agrees with the universal principle in nature that effects are proportionate to amounts,if these last are of the same character. In this instance a certain variation of amounts changes the intensity of Sound, and the variation of amounts of a different character, changes its tone.

X.

GANOT thus refers to sympathetic or unison vibration:

"A singular property of bodies in a state of vibration is that of setting in vibration bodies at rest. Thus, if two tuning forks, tuned so as to give accurately the same note, be at some distance from each other, and one of them be sounded, the other will be set in vibration and emit the same note. But, if one of the forks be put slightly out of tune with the other, by attaching a piece of wax to one prong, for instance, the excitation of either one will have no effect on the other.

"This phenomenon, that a body in a state of vibration has the power of causing an independent body at rest to vibrate in the same period, is called *consonance.*

"If a metal wire freely suspended in the air be tightly stretched and then be set in vibration, the note which it emits will be feeble. So, too, a tuning-fork when sounded gives but a feeble note; but if its stem be held on a table the note becomes far louder.

"The reinforcement of a sound by attaching the sounding body to a large, dry, elastic wooden plate, called a sound-board, or to a wooden box enclosing a mass of air, is called *resonance*; the vibrations of the sounding body are transmitted to the sound-board, which, being set in vibration, communicates its motion to large masses of air.

"Although the terms consonance and resonance are sometimes used indiscriminately, there are distinctions between them.

"Consonance is the excitation of an independent body to vibrate in unison with the sounding body; it begins later than the sounding body, and continues after it has become silent. Resonance begins and ends with the sound of exciting body. A sound-board strengthens and imparts a general sonority to a complex series of notes. The more a body diverges from the form of a plate and approaches that of a rod, the more is its resonance limited to strengthening one or two notes.

"In resonance, however, there is a certain amount of tuning. For the loud and deep notes of the 'cello a large resonance-box is used and a smaller one for higher notes of the violin. Small enclosed volumes of air also strengthen one note in preference."

The statement that the vibrations of the sounding body are transmitted to the sounding-board, is pure humbug, not to call it by a harsher term. How transmitted? The only possible way to transmit the vibrations of a body is to transmit the body itself, but in this case the vibrations referred to are those of the tuning-fork, and to transmit them the tuning-fork would have to be transmitted to the sounding-board, which is not done.

But something is transmitted, that makes a great increase of Sound. What is it? There is only one possible answer—the Sound. Sound is transmitted by a conductor to a board, which, because of its enlarged surface, throws it off much faster than the fork can. And with this self-evident and only possible explanation of what takes place, the undulatory theories are ended. And this is the reason, and only reason, why the truth isn't perceived and told.

Mr. Tyndall in his book "On Sound," makes a similar inexcusable blunder or misstatement. He says:

"The transmission of musical sounds through solid bodies is also capable of easy and agreeable illustration. Before you is a wooden rod, thirty feet long, passing from the table through a window in the ceiling, into the open air above. The lower end of the rod rests upon a wooden tray, to which the musical vibrations of a body applied to the upper end of the rod are to be transferred. An assistant is above with a tuning fork in his hand. He strikes the fork against a pad; it vibrates, but you hear nothing. He now applies the stem of the fork to the end of the rod, and instantly the wooden tray upon the table is rendered musical."

It will be remembered that it isn't the stem, according to this theory, that makes the sound in the air, but the prongs. Mr. Tyndall continues:

"We are now prepared to appreciate an extremely beautiful experiment, for which we are indebted to Sir Charles Wheatstone. In a room underneath this, and separated from it by two floors, is a piano. Through the two floors passes a tin tube two and one-half inches in diameter, and along the axis of this tube passes a rod of deal, the end of which emerges from the floor in front of the lecture table. The rod is clasped by India rubber bands, which entirely close the tin tube. The lower end of the rod rests upon the sound board of the piano, its upper end being exposed before you. An artist is at this moment engaged at the instrument, but you hear no sound. When however, a violin is placed upon the end of the rod, the instrument becomes instantly musical, not, however, with the vibrations of its own strings, but with those of the piano. When the violin is removed, the sound ceases; putting in its place a guitar, the music revives. For the violin and guitar we may substitute a plain wooden tray, which is also rendered musical. Here, finally, is a harp, against the sound board of which the end of the deal rod is caused to press; every note of the piano is reproduced before you. On lifting the harp so as to break the connection with the piano, the sound vanishes; but the moment the sound board is caused to press upon the rod the music is restored. The sound of the piano so far resembles that of the harp that it is hard to resist the impression that the music you hear is that of the latter instrument. An uneducated ear might well believe that witchcraft or 'spiritualism' is concerned in the production of this music."

This use of the word vibration [in this case of a tuning-fork] for Sound, which is repeatedly done in this article, though not in all cases, shows how perfectly unreliable and irresponsible a person becomes when misled by a false theory.

These same experiments of Mr. Wheatstone are thus described by Dr. Neil Arnott, in his excellent "Elements of Physics," published 1827, 7th edition, 1879:

> "The late Sir Charles Wheatstone showed, as far back as 1823, that musical sounds might be readily transmitted through solid linear conductors. An experiment on a large scale was performed at the Polytechnic Institution under an arrangement called the Telephone. Performers on various instruments were placed in the basement of the building, and the sounds which they produced were conducted by solid rods through the principal hall, in which they were inaudible, to sounding-boards in a concert room in an upper floor, where the music was heard by the audience precisely as if it was being performed there."

Dr. Arnott follows the Scotch custom of calling a spade a spade, and Sound, Sound; that is, tells the truth.

In the case of a violin, harp, or piano, many different sounds or notes are transferred to the sounding-board, where a supply of the different sounds is maintained, and thrown into the air, as long as the instruments furnish it, and no longer. In all such cases the principle which operates is resonance. By previous well understood principles consonance or unison vibration would be impossible. That is, unison or sympathetic vibration takes place only when two bodies have the same vibration, it being understood that every elastic body has one and only one normal vibration. And therefore as the instruments referred to make many different sounds, unison vibration of them all by the same body is impossible.

With the undulatory theory of Sound this whole matter is unexplained. With the corpuscular theory, like any other phenomenon of Sound it explains itself.

These sounding boards, whatever their character, always have material connections, aside from air, with the vibrating body which conduct the sound to them in the same manner as that of a tuning-fork is conducted by a deal stick from the fork to the teeth and head.

This sound, in its nature always active, circulates over and perhaps through such sounding boards or boxes, and is thrown off in large quantity by them into the air.

This is a complete explanation of the action of Sound in all such instances, and is the correct one. It alone settles the question of the nature of Sound, proving it to be corpuscular and like electricity a fluid; that is, something which like electricity or a river continues to flow as long as necessary supplies are furnished. Its power of motion, as we have repeatedly said, is innate. It flows through the stick, as naturally as water flows down hill, though not for the same reason.

It will be seen that sympathetic vibration is called consonance; reinforcement by sounding bodies, resonance. Ganot further states that there are distinctions between them, although they are sometimes used indiscriminately. But he does not attempt to explain this difference, as it cannot be done with the undulatory theory.

We have seen with the tuning-fork that sound is made by shock, and makes the vibration. This sound made by shock immediately grows less, and, other things being equal, lessens equably until it ceases. The vibration also diminishes in the same proportion.

That Sound is always made by shock, and in musical instruments is always the cause of the visible vibrations, follows, for nature's laws are universal.

When the stem of the fork is placed upon some body which is a good conductor of Sound, the fork is emptied rapidly; and in either case the vibrations decrease in exact proportion with the Sound, each ceasing at the same moment.

In this case the sound in the fork was started by a blow. The same thing takes place when a piano string, or violin string, or the string of any musical instrument is struck; that is, if these strings are strained to the same tension, they will always produce, when struck, a sound of the same pitch or tone, and in such case can produce no other. It makes no difference how fast or how hard the fork is hit; or the wires when properly fastened. Nor does increased sound then alter the pitch.

It alters the distance in which sounds can be heard,—that is, it alters the intensity of the sound, and this increases the distance that the sound flows, just as an increase of water increases the distance that a stream will flow; and as Sound spreads in all directions from the sounding body as a centre, its intensity or amount diminishes as the square of the distance.

XI.

CHAPTER II. of Ganot treats of the measurement of the number of vibrations, and begins with:

SAVART'S APPARATUS.

"Savart's toothed wheel, so called from the name of its inventor, is an apparatus by which the absolute number of vibrations corresponding to a given note can be determined. It consists of a solid oak frame in which are two wheels, A and B (fig. 1); the larger wheel, A, is connected with the toothed wheel by a strap and a multiplying wheel, thereby causing the toothed wheel to revolve with great velocity; a card, E, is fixed on the frame, and, in revolving, the toothed wheel strikes against it and causes it to vibrate. The card, being struck by each tooth, makes as many vibrations as there are teeth. At the side of the apparatus is an indicator, H, which gives the number of revolutions of the wheel, and consequently the number of vibrations in a given time.

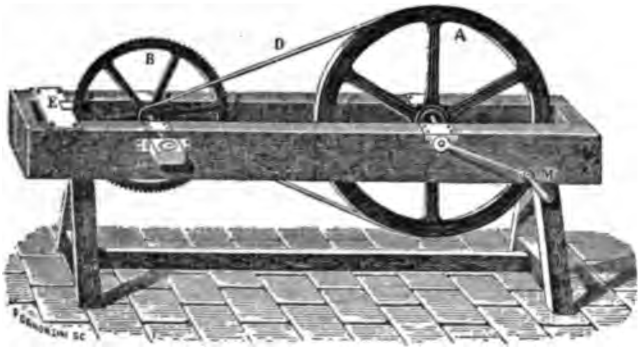

Fig. 1.

"When the wheel is moved slowly, the separate shocks against the card are distinctly heard; but if the velocity is gradually increased, the sound becomes higher and higher. Having obtained the sound whose number of vibrations is to be determined, the revolution of the wheel is continued with the same velocity for a certain number of seconds. The number of turns of the toothed wheel B is then read off on the indicator, and this multiplied by the number of teeth in the wheel gives the total number of vibrations. Dividing this by the corresponding number of seconds, the quotient gives the number of vibrations per second for the given sound."

In the Savart wheel the vibrations of the card-board hit are constantly changed, because its position is constantly changed. And this comes in the nature of the instrument; it couldn't be otherwise; as by the increased speed of the wheel the space through which the struck board falls is lessened. It is, too, perhaps possible that the pitch is raised if the blows come so fast that the card cannot finish its vibrations before it is again struck.

Not, then, the continued striking of a body, however rapidly or strongly this may be done, alters the sound, but such interference with the conditions of the body struck as shall practically make it another body, when the vibrations will be different. With the Savart instrument this is successive and constant, so that in its gamut it represents all bodies.

We can now see why the sound made by this instrument, or any similar instrument, constantly varies; the instrument, in which, or by which, the sound is made is constantly changed.

What then raises the pitch? The answer is very plain: the laws of God; not any operations of man, but a beautiful system wide-spread as the universe, by which every body of a certain form will always, if left to itself, produce a sound of a certain pitch; and these bodies are divided up so thoroughly that sounds of all pitch audible to man are readily reached. And in this way the varieties of sound are produced, and may always be obtained.

And what produces the sound? Always shock produces it. And always the sound produces the vibrations. And always the vibrations are what they are because of the nature of the body which makes them. And evidently the completion of the sounds, and their throwing off into the air, quite similarly as newspapers are thrown off from the press after being printed, depends upon the vibrations. It's what they are for. And these depend upon the interstices of bodies, in which and through which this wonderful electrical force operates. Thus is Sound made and to it is added a power or motion, as wings are to birds,—and thus are they complete to fulfill the mission of their creation. And as their system of motion is fixed and constant, with it they can create bodies that will repeat all sounds, each body the sound which made it.

It takes but an instant to see what a magnificent system this is to furnish the universe with Sounds, the great majority of the bodies in the world contributing. A blow and the sound is forth-coming, of all characters from the roar of the storm to the exquisite notes of a sky-lark, or a human voice.

From these different conditions it appears that Sound in certain forks causes just such a number of vibrations, whose duration depends upon the intensity of the sound when the vibrations begin; that is, at the instant of shock, when the sound is made; and which are equally reduced in length from the first to the last vibration, because of the constant and equal reduction of the sound, from ordinary wear of that in the fork, and loss of that thrown off from the fork.

In addition to this it would seem that the vibration itself might produce more Sound by producing shock or disturbance when hitting the particles of air. Should the vibrating body hit a solid body, it would stop, but in hitting particles of air it does not stop. Such sound however would appear to be of so small intensity as to be negligible.

Following the Savart apparatus is a description of the Sirene, another instrument designed to measure the number of vibrations of a body in a given time. This instrument is rotated by wind, the vibrations being those of air, the body of which is constantly changing with the increased velocity of the movable disk. In describing the plate Ganot says:

> "If the fixed plate, like the moving disk, had eighteen holes, each hole would separately produce the same effect as a separate one, the sound would be eighteen times as intense, but the number of vibrations would not be increased."

As the fixed plate has but one hole, the body of the air is constantly changed when the speed of the machine is continually increased, and therfore the pitch constantly raised, or when the speed is continually reduced, as constantly lowered. The description of this instrument closes as follows:

> "For the same velocity of rotation the sirene gives the same sound in air as in water; the same is the case with all gases; and it appears, therefore, that any given sound depends on the number of vibrations produced and not on the nature of the sounding body."

Every given sound depends upon the mixture of matter of which it is composed. The sounding-body is responsible for its existence, but frequently bodies of different material will perform the same function, as a pitcher, or, as in this case, machinery.

Tuning-forks are made with an arrangement for regulating the rate of vibration by changing the body that vibrates, and this is done by a movable gauge between the prongs, and weights at their ends. The gauge and weights being set, the rate of vibration of the fork will be constant until they are changed, but change these the slightest and a new tone is started. And so as in the Savart wheel, or the Sirene, the whole gamut may be sounded. As the sound in all cases makes the vibrations, these are isochronous from start to finish. For the material of which Sound is composed diminishes uniformly, and therefore the intensity or strength of Sound diminishes uniformly.

These different principles operate in a similar manner in the record of a phonograph or graphophone. Of these instruments Ganot says:

> "If the velocity of rotation increases the pitch of the sound is raised; and if the speed is not uniform, then, in the case of a song, the reproduction is incorrect. In order to produce a uniform velocity the instrument may, with advantage, be driven by clockwork.
>
> "There is a great difference in the distinctness with which the various consonants and vowels are reproduced; the most distinct being words containing the vowels A, O, and U, and the consonants, T, K, and R; the S, and similar consonants, on the contrary, are seldom distinct. If the phonograph be rotated in the reverse direction, the sounds of which the words are made up retain their character, but are reproduced in the reverse order.
>
> "The impressions on the tinfoil appear at first sight as a series of

successive points or dots, but when examined under a microscope they are seen to have a distinct form of their own."

This emphasizes the fact that each indenture represents a particular sound, and, as it takes a large number of them for each word or letter, the manner in which the shading or color of sound takes place is illustrated. The indentures of course are continuous. That is, they follow each other successively precisely as words are spoken or other sounds made. The shading is the result of the mixture,—comes from its varying, which is constant. It might be illustrated by the mixture of any article of food, whilst any ingredient, as flour, or sugar, or salt, was being continuously added, The slightest addition of any one would make a little difference of flavor, whether we recognized it or not. And the merit of the whole article—any article of food we might imagine—would depend,—always depends, other things being equal, upon the combination, although we might not be able to distinguish slight variations.

The same is true of colors, every shade of which,—and these shades are often absolutely continuous,—comes from the variation of the mixture, to which and which alone the colors are due, in precisely the same way that the colors on a painting are due to artificial mixtures of the paint. And undoubtedly, too, the same colors are made by nature or man by the same ingredients, just as a telescope or microscope is made in accordance with the laws of vision. There is no question about this. There is just one mixture that will make any particular shade of color, in the universe. So perfect is the system of law or order by which this universe is constructed.

The same, as we have shown by the excellent article of the renowned French Scientist Ferdinand Papillon, is true of odors, the manufacture of which, as well as of colors, man has been able to duplicate.

Smell a pink fresh from the garden, or the hot-house. A thousand millions, for ought we know, of infinitely small particles of odor comes with a single smell. And these have been manufactured, as has been proven, through the machinery provided by nature, in the air, mainly from carbon and hydrogen, and by the air wafted into the nostrils,—whence comes smell to sentient beings.

In connection we will repeat again from the article of Mr. Papillon, a few very pertinent sentences:

"These rapid details allow us to understand precisely the chemical character of the essences or essential oils which plants elaborate within their delicate tissue. Except a small number among them which contain sulphur, as the essences of the family of crucifers, they all present the same qualitative composition—carbon and hydrogen, with or without oxygen. Between one and another of them merely the proportion of these three composing elements varies by regular gradations, but so as always to correspond either to a hydrocarburet, or to an aldehyde, or to an ether. In this case, as in almost the whole of organic chemistry, everything is in the quantity of the composing elements. The quality is of so little importance to Nature, that, *while following always the same laws, and constantly using the same materials*, she can, by merely changing the ponderable relations of the latter, produce by myriads of various combinations, myriads of substances which have no resemblance to each other.

* * * * * * * *

"Such is the chemical nature of most of the odorous principles of vegetable origin. But chemistry has not stoppcd short with ascertaining the inmost composition of these substances; it has succeeded in reproducing quite a number of them artificially, and the compounds thus manufactured, wholly from elements, in laboratories, are absolutely identical with the products extracted from plants."

XII.

PERHAPS no instrument has ever been invented which has created so much wonder as the graphophone, or more interest. The reproducer passing through the indentures produces a shock, which creates Sound in them. The Sound produces vibration, in the indentures, just as naturally as it does in a tuning-fork, or a piano wire, only the indentures are of infinitesimal character.

In this example, as well as in that of homeopathy, we get a glimpse of a world new to us; a world of infinitesimals and where of necessity all things connected belong to this order. That is, with miniature indentures must come miniature vibrations, but under the same conditions the pitch is the same. For every sounding body has its normal vibration and no other. It has, too, its normal sound, accompanying that vibration. When the speed of the reproducer is increased, it acts as it does with the Savart wheel to raise the pitch, or conversely to lower it.

It is evident again that exactly the same laws operate with Sound, irrespective of the size of the body struck; which would appear to show that there are new phases of our universe as regards size of their phenomena, but governed by precisely similar laws to those with which we are more intimately acquainted.

And so again there are instruments, as a megaphone, to translate to us and make fit in with ours, these productions of a different order of things. So that the sounds which we could hardly hear, enter into competition with those which we are accustomed to.

The cause of rain is moisture in the air, but the density of the clouds and condition of the atmosphere in regard to temperature, circulation and perhaps composition, decide in what form it falls, and how much of it. In either of these cases an ultimate first cause is the amount of material out of which the rain, or Sound, or anything else is made.

That would be a cause of the amount of goods delivered from a saw mill, or cotton, or woolen, or any other mill; but again the amount of goods delivered in every case would also depend upon the action of the machinery of the mills.

In either of the cases it would be true, if the mill made the goods without material to make them from, that goods primarily and only depended upon the action of the mills; but this is one of the many things that are impossible under the laws of nature, as much so as that the diafram of a telephone should repeat the sounds of the universe, or that any others of the fixed and eternal laws of God, by which the universe was constructed, and upon which its operations depend, should cease to act. Ultimately the sound delivered depends upon the amount of it made by the shock, less that which perished before delivery; and this again must depend upon the material at hand to make it, when the shock takes place.

We say the cotton mill makes the cotton goods, which in one sense is correct; but it doesn't make the cotton. A mill might be a sufficient cause for the quality of goods delivered, but could not be for the cotton, or wool, or silk, or anything from which the different goods are made. And sound is no exception to this. There are no exceptions; nature's laws are universal, and unalterable. They are, too, the same, as repeatedly shown in "Ellen," whether the things made by them are natural or artificial. This cannot be too generally understood. Because of the ignorance of such fundamental principles do the mistakes in physics arise. A foundation for knowledge is as indispensable as for a building.

In nature every cause has to be provided for, before a sufficient cause is sustained; and always there must be a cause for a cause, and a sufficient one. That is, there is to every thing a series of sufficient causes, until we come to the ultimate cause of all, an infinite God, self-sustaining and eternal; that Power which wills and a thing is done.

In the operations of nature there would appear to be no way by which any substance is changed, except by addition or diminution, one or both. In the change of tone Sound undergoes an essential change, which as would appear from the Dopler principle is caused by an increased quantity of the same quality of sound reaching the sense of hearing in a given length of time, as a second; the tone being raised if the quantity of sound is increased, and lowered if it is diminished.

But as Sound concerns disturbance, that is, matter in motion, those things which affect it have to do with matter in motion, and perhaps only with matter in motion, of which there must be many kinds, as we often see illustrated in fire-works.

Ganot thus describes the Phonautograph:

> "This apparatus registers not only the vibrations [sounds] produced by solid bodies, but also those produced by wind instruments, by the voice in singing, and even by any noise whatsoever; for instance, that of thun-

der, or the report of a cannon. It consists of an ellipsoidal barrel, AB (fig. 2), about a foot and a half long and a foot in its greatest diameter, made of plaster of Paris. The end A is open, but the end B is closed by a solid bottom, to the middle of which is fixed a brass tube *a*, bent at an elbow and terminated by a ring, on which is fixed a flexible membrane which, by means of a second ring, can be stretched to the required extent. Near the centre of the membrane, fixed by sealing-wax, is a hog's bristle, which acts as a style, and of course, shares the movements of the membrane. In order that the style shall not be at a *node*, the stretching ring is fitted with a movable piece, *i*, or *subdivider*, which, being made to touch the membrane first at one point and then at another, enables the experimenter to alter the arrangements of the nodal lines at will. By means of the subdivider, the point is made to coincide with a loop; that is, a point where the vibrations of the membrane are at a maximum.

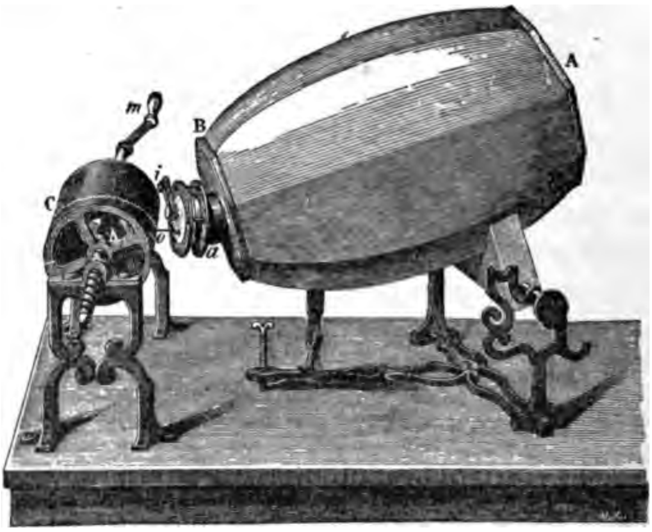

Fig. 2.

"When a sound is produced near the apparatus, the air in the ellipsoid, the membrane, and the style will vibrate in unison with it, and it only remains to trace on a sensitive surface the vibrations of the style, and to fix them. For this purpose there is placed in front of the membrane a brass cylinder, C, turning round a horizontal axis by means of a handle, *m*. On the prolonged axis of the cylinder a screw is cut which works in a nut; consequently, when the handle is turned, the cylinder gradually advances in the direction of its axis. Round the cylinder is wrapped a sheet of paper covered with a thin layer of lamp black.

Fig. 3.

Fig. 4.

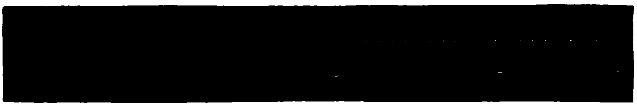

Fig. 5.

"The apparatus is used by bringing the prepared paper into contact with the point of the style, and then setting the cylinder in motion round its axis. So long as no sound is heard, the style remains at rest, and merely removes the lampblack along a line which is a helix on the cylinder, but which becomes straight when the paper is unwrapped. But when a sound is heard the membrane and the style vibrate in unison, and the line traced out is no longer straight, but undulates, each undulation corresponding to a double vibration of the style. Conse-

> quently, the figures thus obtained faithfully denote the number, amplitude, and isochronism of the vibrations.
>
> "Fig. 3 shows the trace produced when a simple note is sung, and strengthened by means of an upper octave. The latter note is represented by the curve of lesser amplitude. Fig. 4 represents the sound produced jointly by two pipes whose notes differ by an octave. The lower line or fig. 5 represents the rolling sound of the letter R when pronounced with a ring.
>
> "The upper line of fig. 5 represents the perfectly isochronous vibrations of a tuning-fork placed near the ellipsoid. This line was traced by a fine point on one branch of the fork, which was thus found to make exactly 500 vibrations per second. Hence, each undulation of the upper line corresponds to the $\frac{1}{500}$ part of a second; and thus these lines become very exact means of measuring short intervals of time. For example, in fig. 5 each of the separate shocks producing the rolling sound of the letter R corresponds to about 18 double vibrations of the tuning-fork, and consequently lasts about $\frac{18}{500}$ or about $\frac{1}{28}$ of a second."

As suggested by Mr. Ganot, this instrument operates by the principle of unison vibration, which is accomplished through the sub-divider. That is, by the use of this instrument the membrane may be made to vibrate to many and perhaps all different sounds, each sound entering the membrane, and, because it is in unison, causing it to vibrate.

A description of König's Manometric flames follows:

> König's method consists in transmitting sound to gas flames, which, by their pulsations, indicate the nature of the sounds. For this purpose a metal capsule, represented in section at A, fig. 6, is divided into two compartments by a thin membrane of caoutchouc; on the right of

the figure is a gas jet, and below it a tube conveying coal gas; on the left is a tubulure, to which may be attached a caoutchouc tube. The other end of this may be placed at the node of an organ pipe, or it terminates in a mouth-piece in front of which a given note may be sung: this is the arrangement represented in fig. 6.

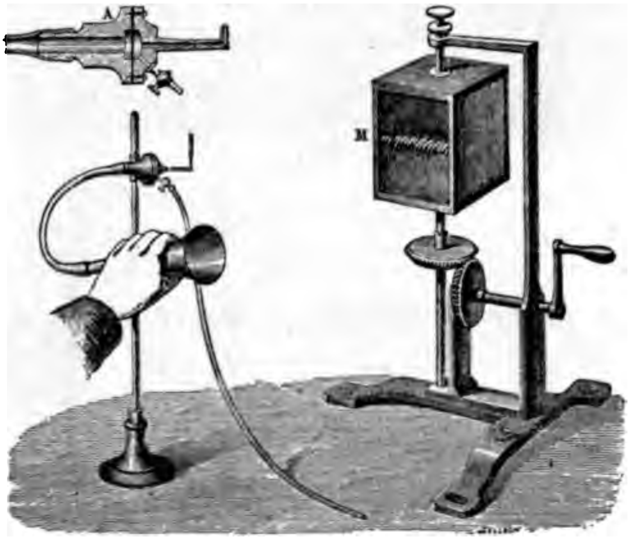

Fig. 6.

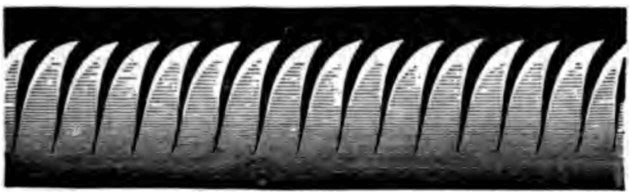

Fig. 7.

"When the sound enters the capsule by the mouthpiece and the tube, the membrane yielding to its vibrating action, the coal gas in compartment on the right is alternately contracted and expanded, and hence are produced alternations in the length of the flame, which are, however, scarcely perceptible when the flame is observed directly. But to render them distinct they are received on a mirror with four faces, M, which may be turned by two cog-wheels and a handle. As long as the flame burns steadily, there appears in the mirror, when turned, a continuous band of light. But, if the capsule is connected with a sounding-tube yielding the fundamental note, the image of the flame takes the form represented in fig. 7, and that of figure 8 if the sound yields the octave. If the sounds reach the capsule simultaneously, the flame has the appearance of fig. 9; in that case, however, the tube leading to the capsule must be connected by a T-pipe with two sound-

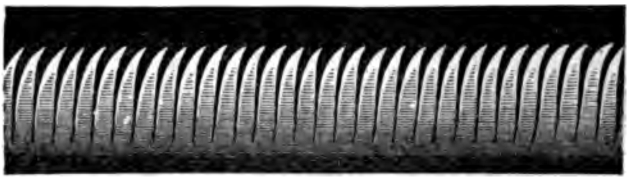

Fig. 8.

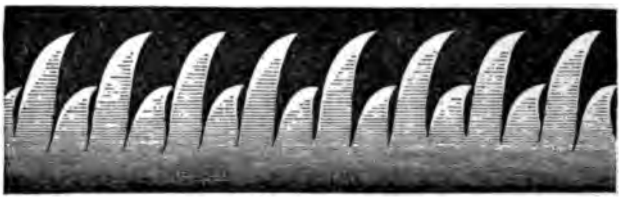

Fig. 9.

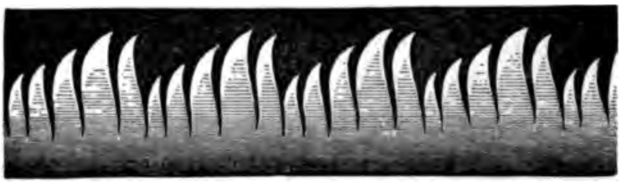

Fig. 10.

ing-tubes, one giving the fundamental note, and the other the octave. If one gives the fundamental note and the other the third, the flame has the appearance of figure 10.

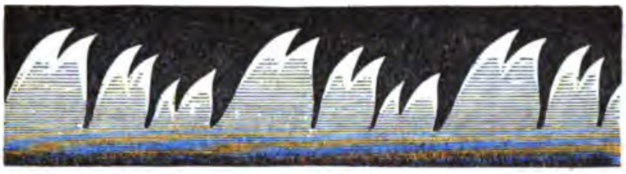

Fig. 11.

If the vowel E be sung in front of the mouthpiece, first upon *c*, and then upon *c*′, the mirror gives the flames represented in figs. 11 and 12."*

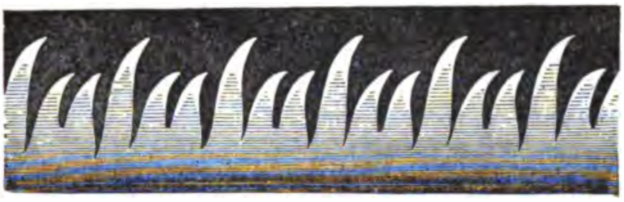

Fig. 12.

From the foregoing it will be perceived, that each different Sound produces a different movement in the body it is in.

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* The above is given mainly in Ganot's language, entirely so in the last part where Sound is called Sound.

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XIII.

UNDER Reflection of Sound, Ganot says:

"So long as sound-waves are not obstructed in their motion they are propagated in the form of concentric spheres; but when they meet with an obstacle they follow the general law of elastic bodies; that is, they return upon themselves, forming new concentric waves, which seem to emanate from a second centre on the other side of the obstacle. This phenomenon constitutes the reflection of sound."

This is all the purest nonsense. Reflection of any kind of a wave made from a mobile fluid so as to preserve its form is inconceivable. The necessity of it is enough to demolish this theory, and should have prevented anyone from ever accepting it. Air never reflects under such conditions. Because of its mobility the most it can do is to return to those spaces which the impelling body leaves behind it. Mr. Airy at one time Astronomer Royal of England, says in the "London, Edinburgh and Dublin Philosophical Magazine," vol. 33, page 404:

"I have never been able to observe the smallest trace of reflected wave from a surf, although at the same time I am utterly unable to account for the disposal of the *vis viva.*

* * * * * * * *

"A broken-headed sea is not reflected by a vertical pier. When a broken-headed sea strikes a pier perpendicularly, it is thrown upwards; when it strikes obliquely, it is partly thrown upwards and partly it runs horizontally along the face of the pier. In neither case is there any reflection of the broken-head, or any creation of a broken wave traveling in the opposite direction, although the swell is reflected according to the usually understood laws."

The reflection of the sound is complete, but it is the reflection of particles of matter, made so that they can reflect, and this reflection, which includes echoes, is a beautiful addition to the principle of Sound.

Sir J. F. W. Herschel says:

> "When Sound in the course of its propagation meets with an obstacle of sufficient extent and regularity it is reflected, producing the phenomenon we call Echo. A wall, the side of a house, or the surface of a rock, the ceiling, floor, and walls of an apartment, the vaulted roof of a church, all under proper circumstances, give rise to Echoes more or less audible. The reflected Sound meeting another such obstacle is again reflected, and thus the Echo may be repeated many times in succession, becoming however fainter at each repetition until it dies away altogether."

Of Refraction of Sound, Ganot says:

> "It will be found afterwards that *refraction* is the change of direction which light and heat experience on passing from one medium to another. It has been shown by Hajech that the laws of the refraction of sound are the same as those for light and heat: he used tubes filled with various gases and liquids, and closed by membranes: the membrane at one end was at right angles to the axis of the tube, while the other made an angle with it. When these tubes were placed in an aperture in the wall between two rooms, a sound produced in front of the tube in one room, that of a tuning-fork for instance, was heard in directions in the other varying with the inclination of the second membrane, and with the nature of the substance with which

the tube was filled. Accurate measurements showed that the law held that the sines of the angle of incidence and of refraction are in a constant ratio, and that this ratio is equal to that of the velocity of sound in the two media.

"Thus the velocity of sound in water is not very different from that in hydrogen, and they produce deviations which are nearly equal.

"Sondhauss confirmed the analogy of the refraction of sound to those of light and heat. He constructed lenses of gas by cutting equal segments out of a large colodion balloon, and fastening them on the two sides of a sheet-iron ring a foot in diameter, so as to form a double convex lens about 4 inches thick in the centre (fig. 13). This was filled

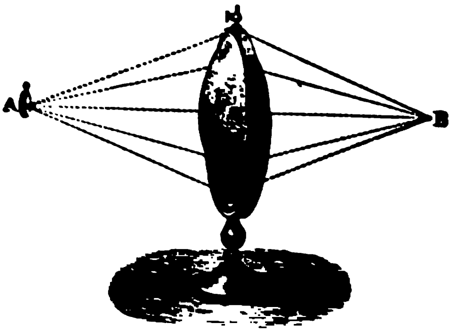

Fig. 13

with carbonic acid, and a watch A was placed in the direction of the axis. The point was then sought on the other side of the lens at which the sound was most distinctly heard. It was found that when the ear was removed from the axis the sound was scarcely perceptible, but that at a certain point B on the axis line it was very distinctly heard. Consequently the sound-waves in passing from the lens had converged towards the axis; their direction had been changed; in other words they had been refracted.

What is true of reflection is true of refraction. Sound

sound-waves could neither refract or reflect, but sound particles are wonderfully adapted to do both; and the above experiments demonstrate, in addition, that Sound, Heat and Light are all similarly made. It may be seen here that Ganot uses the word "sound-wave" but once, to "sound" eight times.

Von Helmholtz's analysis of Sound is thus spoken of:

> " For the purpose of experimentally proving the presence of the harmonics as distinct tones, Von Helmholtz devised an instrument which he called a *resonance-globe*. The use of this apparatus may be illustrated by the following experiment:—If an empty glass cylinder be taken, and a vibrating tuning-fork be held over the mouth of the vessel, the air will not be set in vibration unless it be of a certain definite length. Now, by pouring in water we can regulate the length of the column of air, and by trial can hit off the exact length; when this is attained the note of the tuning-fork will be heard to be powerfully reinforced. A resonance-globe fig. 14 is a glass or brass globe tuned to a particular note furnished with two openings, one of which, *a* is turned towards the origin of the sound, and the other, *b*, by means of an india-rubber tube, is applied to the ear. If the note proper to the resonance-globe exists among the harmonics of the compound note that is sounded, it is strengthened by the globe, and thereby rendered distinctly audible. Further, other things being the same, the note proper to a given globe depends on the diameter of the globe and that of the uncovered opening. Consequently, by means of a series of such globes, the whole

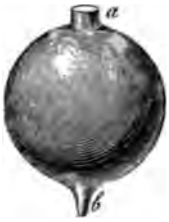

Fig. 14.

Fig. 15.

series of harmonics in a given compound tone can be rendered distinctly audible, and their existence put beyond a doubt.

" König, the eminent acoustical-instrument maker, has made an important modification in the resonance-globe, to which he has given the form represented in fig. 15. The resonator is cylindrical, and the end which receives the sound can be drawn out, so that the volume may be increased at pleasure. As the sound thereby becomes deeper, the same resonator may be tuned to a variety of notes."

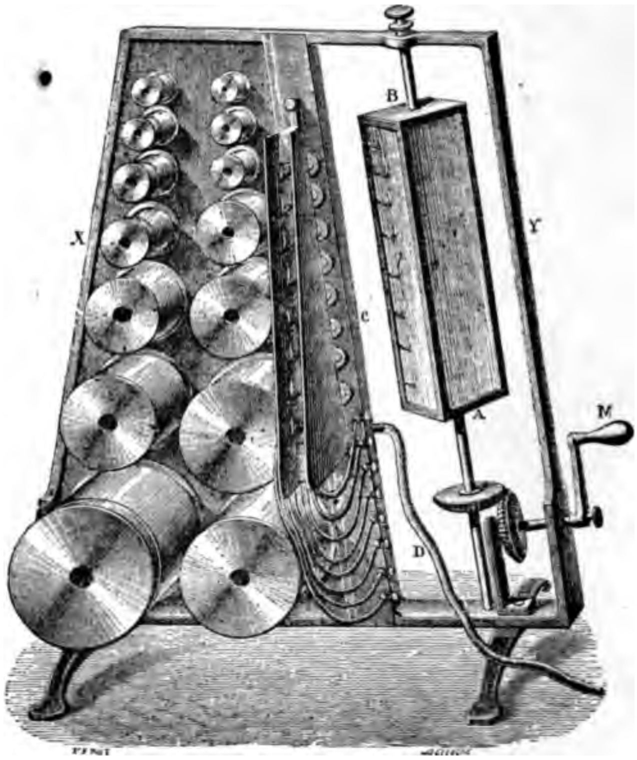

Fig. 16.

Both of these instruments operate through the principle of unison vibration. Columns of air are made, which can be thrown into vibration, and are thrown into vibration by Sound.

This principle of unison vibration is again illustrated by König's apparatus for the analysis of Sound, described as follows:

> "As the successive application to the ear of various resonators is both slow and tedious, König devised a remarkable apparatus in which a series of resonators act on manometric flames [page 96]; the sounds thus, as it were, become visible and may be shown to a large auditory.
>
> "It consists of an iron frame (fig. 16), on which are fixed in two parallel lines fourteen resonators tuned so as to give the notes from $F_{,}$ to c''—that is to say, three octaves and a half; or notes of which the highest give the lower harmonics of the primary. On the right is a chamber, C, which is supplied with coal gas by the caoutchouc tube D, and on which are placed eight gas-jets, each provided with a manometric capsule [page 96]. Each jet is connected with the chamber C by a special caoutchouc tube, while behind the apparatus a second tube connects the same jet to one of the resonators. On the right of the jets is a system of rotating mirrors identical with that described on page 97.
>
> "These details being understood, suppose the largest resonator on the right tuned to resound with the note 1, and seven others with the harmonics of this note. Let the sound 1 be produced in part of this apparatus; if it is simple, the lower resonator alone answers, and the corresponding flame is alone dentated; but if the fundamental note is accompanied by one or more of its harmonics, the corresponding resonators speak at the same time, which is recognized by the dentation of their flames; and thus the constituents of each sound may be detected."

"**Synthesis of sounds.**—Not only did Von Helmholtz succeed in decomposing sounds into their constituents; he also verified the results of his analysis by performing the reverse operation, the synthesis; that is, he reproduced a given sound by combining the individual sounds of which his resonators had shown that it was composed. The apparatus which he used for this purpose consists of eleven tuning-forks, the first of which yields the fundamental note of 256 vibrations, or C, nine others its harmonics, while the eleventh serves as make and break to cause the tuning-forks to vibrate by means of electro-magnets. Each tuning-fork has a special electro-magnet, and moreover a resonator, which strengthens it.

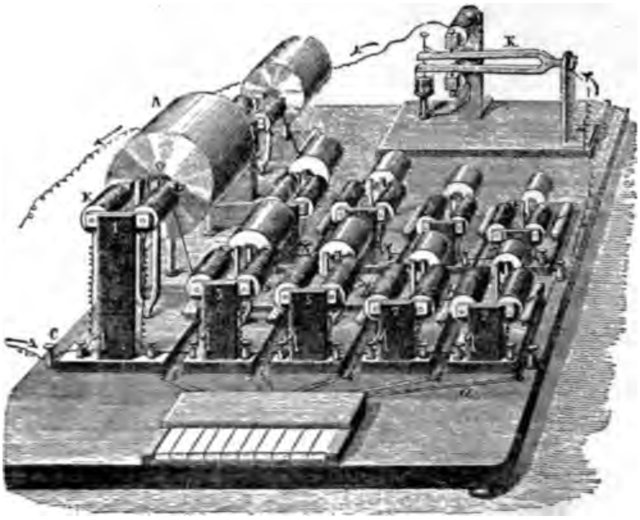

Fig. 17.

"All these tuning-forks and their accessories are arranged in parallel lines of five (fig. 17), the first comprising the fundamental note and its uneven harmonics, 3, 5, 7, and 9; the second the even harmonics, 2, 4, 6, 8, and 10; beyond, there is the tuning-fork break, K, arranged horizontally. One of its prongs is provided with a platinum point which grazes the surface of mercury contained in a small cup, the bottom of which is connected by a copper wire with an electro-magnet placed in front of the fork.

"The apparatus being thus arranged, a wire from a voltaic battery is connected with the binding-screw, *c*, and this with the electro-magnet, E; which in turn is connected with those of the nine following tuning-forks, and then with the fork, K, itself. So long as the latter does not vibrate the current does not pass, for the platinum point does not dip in the mercury cup which is connected with the other pole of the battery. But when the fork is made to vibrate by means of a bow, the current passes. Owing to their elasticity, the limbs of the tuning-fork soon revert to their original position, the point is no longer in the mercury, the current is broken, and so on at each double vibration of the fork. The intermittence of the current being transmitted to all the other electro-magnets, they are alternately active and inactive. Hence they communicate to all the forks by their attraction the same number of vibrations. This is the case with the fork 1, which is tuned in unison with the forkbreak; but the fork 3, being tuned to make three times as many vibrations, makes three vibrations at each break of the cur-

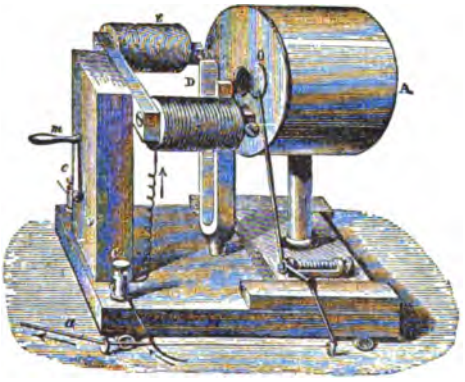

Fig. 18.

rent; that is to say, the electro-magnet only attracts it at every third vibration; in like manner, fork 5 only receives a fresh impulse every five vibrations, and so on.

"The following is the working of the apparatus:—The resonator of each tuning-fork may be closed by a disc, O (fig. 18), so that the sound made by it is scarcely perceptible when the disc is lowered. Each disc is fixed on the end of a bent lever, the shorter arm of which is worked by a cord, *a*, which is connected with one of the keys of a keyboard placed in front of the apparatus (fig. 17). When a key is depressed, the cord moves the lever, which raises the clapper, and the resonator then acts by strengthening its fork. Hence by depressing a special key we may add to the fundamental sounds any of the nine primary harmonics, and thus reproduce the sounds, the composition of which has been determined by analysis. Thus by depressing all the keys at once we obtain the sound of an open pipe in unison with the deepest tuning-fork. By depressing the key of the fundamental note and those of its uneven harmonics, we obtain the sound of a closed pipe."

Referring to the Results of Von Helmholtz's researches.— Ganot says further:

"By both his analytical and synthetical investigations into sounds of the most varied kinds—those from various musical instruments, the human voice, and even noises—von Helmholtz fully succeeded in explaining the different *timbre* or quality of sounds. It is due to the different intensities of the harmonics which accompany the primary tones of these sounds. The leading results of these researches into the colour of sounds may be thus stated:—

"Simple sounds, as those produced by a tuning-fork with a resonance-box, and by wide covered pipes, are soft and agreeable, without any roughness, but weak, and in the deeper notes dull.

"Musical sounds accompanied by a series of harmonics, say up to the sixth, in moderate strength, are full and rich. In comparison with simple tones they are grander and more sonorous. Such are the sounds of open organ-pipes, of the pianoforte, etc.

"If only the uneven harmonics are present, as in the case of narrow stopped pipes, of pianoforte strings struck in the middle, &c., the sound becomes indistinct; and, when a greater number of harmonics is audible, the sound acquires a nasal character.

"If the harmonics beyond the sixth and seventh are very distinct, the sound becomes sharp and rough. If less strong, the harmonics are not prejudicial to the musical usefulness of the notes. On the contrary, they are useful as imparting character and expression to the music. Of this kind are most stringed instruments, and most pipes furnished with tongues, &c. Sounds in which harmonics are particularly strong acquire thereby a peculiarly penetrating character; such are those yielded by brass instruments.

Production of vocal sounds—"The *treachea* or *windpipe* is a tube which terminates at one end in the lungs, and at the other in the *larynx*, which is the true organ of vocal sound. Fig. 19 represents a horizontal section of this organ. It consists of a number of cartilaginous structures, *bb*, which are connected by various muscles, by which great variety and control in the motions are attainable. These mus-

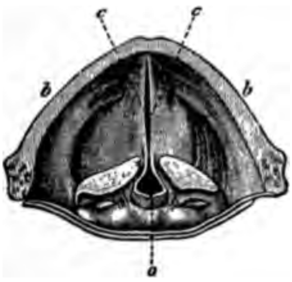

Fig. 19.

cles are connected with, and move, two elastic membranes or bands with broad bases fixed to the larynx, and with sharp edges, *cc*; these are called the *vocal cords.* According to the pressure of the muscles, these cords are more or less tightly stretched, and the space between them, the *vocal slit,* is narrower or wider accordingly. In ordinary breathing, air passes through the triangular aperture *o*; but when in singing this is closed, the vocal cords are stretched and are put in vibration by the current of air, and produce tones which are higher the more tightly the cords are stretched and the narrower is the vocal slit. These changes can be effected with surprising rapidity, so that in this respect the human voice far exceeds anything that can be made artificially.

"The notes produced by men are deeper than those of women or boys, because in them the larynx is longer and the vocal cords larger and thicker; hence, though equally elastic, they vibrate less swiftly. The vocal cords are 18 mm. long in men, and 12 mm. long in women. Chest notes are due to the fact that the whole membrane vibrates, while the falsetto is produced by a vibration of the extreme edges only. The ordinary compass of the voice is within two octaves, though this is exceeded by some celebrated singers. Catalini, for instance, is said to have had a range of 3½ octaves.

"To form a given vowel sound one or more characteristic notes which are always the same must be added. These change with the syllable pronounced, but depend neither on the height of the note, nor on the person who emits them.

"The sound of the human voice is very complex and rich in harmonics, for the mouth and the various cavities opening into the mouth act as resonators; as the note changes with their extent, with the degree to which the mouth is opened and the shape given to it, certain harmonics are strengthened or not, and thus the voice acquires a different timbre.

Perception of sounds. The ear—"The organ of hearing in man consists of several structures; there is first the outer ear (fig. 20) by which the sound is collected and transmitted through the auditory passage, *a*, to the *drum* or *tympanum, t.* This is a delicate tightly stretched membrane or skin which separates the outer ear from the middle ear or *tympanic cavity*, which is a cavity in the temporal bone in which are several bones whose dimensions are considerably exaggerated in the figure. One of these, the *hammer d*, is attached at one end to the *drum*, and at the other is jointed to the *anvil, e*; the latter is connected by means of the *stirrup bone, f*, to the *oval window*, an aperture closed by a fine membrane, which separates the tympanic cavity from the *labyrinth.* The tympanic cavity is also connected by the *Eustachian tube, b*, with the cavity of the mouth, so that the air in it is always under the same pressure.

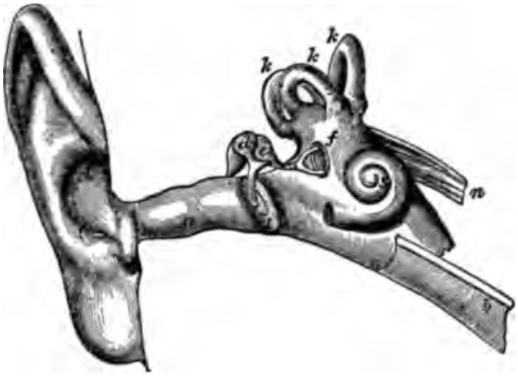

Fig. 20.

"The labyrinth is a complicated structure filled with fluid; it is entirely of bone, with the exception of the oval window already mentioned and the *round window, o.* The labyrinth consists of three parts: the *vestibule*, which is closed by the oval window; the three semicircular canals, *k*; and the spiral-shaped *cochlea*, or snail shell, *s.* This is separated throughout its entire length by a division partly of bony projection and partly of membrane; the upper part of this division is connected with the vestibule, and therefore with the oval window, while the lower part is connected with the round window. In the labyrinthine fluid of this part the termination of the auditory nerve is spread, the other end leading to the brain.

"The membranous part of this diaphragm is lined with about 3,000 extremely minute fibres, which are the terminations of the acoustic nerve, *n*. Each of these, which are called *Corti's fibres*, seems to be tuned for a particular note as if it was a small resonator. Thus when the vibrations of any particular note reach these fibres, through the intervention of the stirrup bone and the fluid of the labyrinth, one fibre or set of fibres only vibrate in unison with this note, and is deaf for all others. Hence each simple note causes only one fibre to vibrate, while compound notes cause several; just as when we sing with a piano only the fundamental note and its harmonics vibrate. Thus, however complex external sounds may be, these microscopic fibres can analyse them and reveal the constituents of which they are formed."

Let the crude idea of air being intimately connected with Sound, except as a medium to carry it, be eliminated from the science, there remains a clear, beautiful theory which reflects great honor upon those gentlemen who have thoroughly and most successfully worked out these difficult parts of it. Unfortunately the stupidity connected with the undulatory department has prevented nearly all from realizing the wonderful beauty and marvelous skill in which the system is designed. Probably the sensation of Light is the most wonderful sensation of all in which man is directly interested. But, whilst now a clear glimpse is had of Sound, as yet we have no such of Light.

Here, too, we will hope that, the undulatory system being abandoned and the corpuscular one as worked out by Sir Isaac

Newton again accepted, there will follow an exposition on Light even more beautiful, and equally complete with that of Sound.

But in doing this the New Physics will have to be recognized in the nature of motion—that it is matter in motion, and as such is introduced into bodies, similarly to other matter, in such manner and at such times as it may be wanted. Sound, which is the result of disturbance, illustrates this very fully; and, artificially, fire works would appear to do the same.

XIV.

IN an article upon Sound, published in the Rees' Cyclopædia 1802–19, we find:

"To explain this [the vibration of musical bodies] all sensible bodies are *supposed* to consist of a number of small and insensible parts or corpuscles, which are of the same nature in all bodies, and are perfectly hard and incompressible.*

"Of these are composed others, somewhat greater, but still insensible; and these different, according to the different figures and union of their component parts. These, again, constitute other masses, bigger and more different than the former; and of the various combinations of these last, are those gross bodies composed that are visible, tangible, &c. The first and smallest parts, we have observed, are absolutely hard; the others are compressible, and are united in such manner, that, being compressed by an external impulse, they have an elastic or restitutive power, by which they restore themselves to their natural state.

"A shock, then, being made by one body upon another, the small particles, by their elastic principle, move to and again with a very great velocity, in a tremulous, undulating manner, somewhat like the visible motions of grosser springs; as we easily observe in the strings of musical instruments. And this is what we may call the *sonorous motion*, which is propagated to the ear; but observe, that it is the *insensible* motion of those particles next the smallest, which is *supposed* to be the immediate cause of sound; and, of these only those next the surface communicate with the air, the motion of the whole, or of the greater parts, being no farther concerned, than as they contribute to each other.

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* Sir H. F. W. Herschel who accepts the above hypothesis to explain the visible vibration of musical bodies, adds: "The molecules of fluids are capable of displacement between themselves. Those of solids, on the other hand, are subjected to the condition of never changing their order of arrangement."

"To apply this theory, strike a bell with any hard body, and you easily perceive a sensible tremor on the surface, spreading itself over the whole, and that more sensibly as the shock is greater. Upon touching it in any part, the motion and the sound too are stopped. Now this is *apparently* a motion of the small and insensible parts, changing their situation, with respect to one another; which being so many, and so closely united, we cannot perceive their motions separately and distinctly; but only a trembling which we *reckon* to be the effect of the confusion of an infinite number of little particles, closely joined, and only moving in infinitely little lines.

"M. Perrault adds, that the visible motion of the parts contributes not otherwise to sound, than as it causes the invisible motion of the smaller parts, which he calls *particles*, to distinguish them from the sensible ones, which he calls *parts*, and from the smallest of all, which we call *corpuscles*."

Here is the ground work of this theory, so far as it refers to vibration, the author being honest enough to remind us several times that the whole thing is an hypothesis, or rather a series of hypotheses. But an hypothesis is at the best only an opinion, which Socrates tersely declared as "bad all." These certainly are particularly bad, being used to explain a thing which readily explains itself—the visible oscillations of musical instruments. But it is the one upon which this theory rests to-day, and similar hypotheses enter into other parts of science.

It is in such cases that the destructive force of hypotheses may be seen, for soon they are stated as facts, thus accepted, and sometimes prevent the discovery of a simple and perhaps very important truth for many centuries. Certainly Faraday's eloquent period against their use couldn't be too strong. For to them are due nearly all the blunders, exposed and unexposed, that so greatly mar science, reducing its usefulness to a minimum, and indeed frequently for years, and sometimes almost ages, preventing discovery of truth.

Such hypotheses answer commercial purposes in advancing the interests of teachers, and increasing the sale of text-books; and therefore is it, whether recognized or not, that they are permitted to remain.

We find two articles in the London Encyclopædia, edition published 1827, quite remarkable as throwing much light upon the earlier theories in regard to Sound, and the gradual adoption of the undulatory theory, but only after very determined opposition to it by many.

The first article is under Acoustics in Vol. I., and the last article under Sound in Vol. XX. The name of the author does not appear, but he is evidently an honest man and an able one.

These articles will be found in part in the Preface of this book. The conclusion of the first article is as follows:

> "That air is the principal vehicle of sound is universally allowed; and, that without the medium of it, or some other fluid, we should ordinarily have no sounds at all, is proved by the experiment of a receiver, exhausted of its air, in an air-pump, when a bell, rung in the vacuum, makes no sound whatever: the fact is also now confirmed, that the force of the pulsations depend considerably upon the degree of density, or rarefaction of the air. Dr. Priestley, to ascertain whether the intensity of sound is affected by any other property of the air besides its density, provided an apparatus, with which he performed sev-

eral experiments, and at last came to the conclusion that the intensity of sound depends solely upon the density of the surrounding air, and not in any measure upon any chemical principle in its constitution. In inflammable air of ten times the rarefaction of common air, the bell could be scarcely heard. In fixed air, the sound could be heard about half as far again as in common air, owing to the superior density of that air. In dephlogisticated air, the sound was sensibly louder than common air. Mr. Hauksbee, also made many experiments of a similar nature, in air of different degrees of condensation, in the course of which, a bell was heard at the distance of thirty yards in common air, at sixty with the force of two atmospheres, and as far as ninety with the force of three. (Philosophical Transactions, 1709, xxiv. 1904, xxvi. 367, 371)."

The following is from the article on Sound in Vol. XX., referred to above:

"But in later times, during the ardent researches in the seventeenth century into the phenomena of nature, this became an interesting subject of enquiry. The invention of the air-pump gave the first opportunity of deciding by experiment whether the elastic undulations of air were the causes of sound and the trial established this point; for a bell rung in vacuo gave no sound, and one rung in condensed air gave a very loud one. It was therefore received as a doctrine in general physics that air was the vehicle of sound."

It is evident to any one that this experiment warranted no such conclusion. It might mean that some substantial medium was necessary for the transmission of Sound, or that air was important in its manufacture, or both. See experiments by Hauksbee, pages—66, 71.

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"Many experiments are mentioned by Kircher and others on the communication of sound through solid bodies, such as masts, yards, and other long beams of dry fir, with similar results. Dr. Monro has published a particular account of very curious experiments on the propagation of sound through water, in his Dissertation on the Physiology of Fishes; so that it now appears that air is by no means the only vehicle of sound. In 1760 Cotunni published his important discovery that the labyrinth or inmost cavity of the ear in animals is completely filled with water. This, after some contest, has been completely demonstrated (see Meckle Junior de Labyrinthi Auris Contentis, Argentor, 17-77), and it seems now to be admitted by all. This being the case, our notions of the immediate cause of sound must undergo a great revolution, and a new research must be made into the way in which the nerve is affected; for it is not enough that we substitute the undulations of water for those of air in the labyrinth. The well informed mechanician will see at once, that the vivacity of the agitations of the nerve will be greatly increased by this substitution; for if water be perfectly elastic, through the whole extent of the undulatory agitation which it receives, its effect will be greater in proportion to its specific gravity: and this is confirmed by an experiment very easily made. Immerse a table bell in water contained in a large thin glass vessel. Strike it with a hammer. The sound will be heard as if the bell had been immediately struck on the sides of the vessel. The filling of the labyrinth of the ear with water is therefore an additional mark of the great wisdom of the Great Artist. But this is not enough for informing us concerning the ultimate mechanical event in the process of hearing. The manner in which the nerve is exposed to these undulations must be totally different from what was formerly imagined. The filaments and membranes which have been described by former anatomists must have been found by them in a state quite unlike to their situation and condition in the living animal. Accordingly the most eminent anatomists of Europe seem at present in great uncertainty as to the state of the auditory nerve, and are keenly occupied in observations to this purpose. The descriptions given by Monro, Scarpa, Camper, Comparetti, and others, are full of most curious discoveries, which make almost a total change in our notions of this subject, and will, we hope, be productive of most valuable information. Scarpa has discovered that the solid cavity called the labyrinth, contains a threefold expansion of the auditory nerve. One part of it, the cochlea, contains it in a fibrillous state, ramified in a most symmetrical manner through the whole of the zona molis of the lamina spiralis, where it anastomoses with another production of it diffused over the general lining of that cavity. Another department of the nerve, also in a fibrous state, is spread over the external surface of a membranaceous bag, which nearly fills that part of the vestibule into which the semicircular canals open, and also that orifice which receives the impressions of the stapes. This bag sends off tubular membranaceous ducts, which, in like manner, nearly fill these semi-circular canals. A third department of the nerve is spread over the external surface of another membranaceous bag, which lies between the one just now mentioned and the cochlea, but, having no communication with either, almost completely filling the remainder of the vestibule. Thus the vestibule and canals seem only a case for protecting this sensitive membranaceous vessel, which is almost but not altogether in contact with the osseous case, being separated by a delicate and almost fluid cellular substance. The fibrillous expansion of the nerve is not indiscriminately diffused over the surface of these sacculi, but evidently directed to certain foci, where the fibres are constipated. And this is the last appearance of the fibrous state of the nerve; for, when the inside of these sacculi is inspected, no fibres appear, but a pulp (judged to be nervous from its similarity to other pulpy productions of the brain) adhering to the membranaceous coat, and not separable from it by gently washing it. It is more abundant, that is of greater thickness, opposite to the external fibrous foci. No organical structure could be discovered in this pulp, but it probably is organised; for, besides this adhering pulp, the water in the sacculi was observed to be clammy or mucous; so that in all probability the vascular or fibrous state of the nerve is succeeded by an uninterrupted production (perhaps columnar like basalt, though not cohering); and this at last ends in simple dissemination, symmetrical, however, where water and nerve are alternate in every direction. To these observations of Scarpa, Comparetti adds the curious circumstances of another and regular tympanum in the foramen rotundum, the cylindric cavity of which is enclosed at both ends by a fine membrane. The membrane which separates it from the cochlea appears to be in a state of variable tension, being drawn up to an umbo by a cartilaginous speck in its middle, which he thinks adheres to the lamina spiralis, and thus serves to strain the drumhead as the malleus strains the great membrane known to all. These are most important observations, and must greatly excite the curiosity of a truly philosophical mind, and deserve the most careful enquiry into their justness. If these are accurate descriptions of the organ, they seem to conduct us farther into the secrets of nature than any thing yet known. They promise to give us the greatest step yet made in physiology, viz. to show us the last mechanical fact which occurs in the long train interposed between the external body and the incitement of our sensitive system."

XV.

WE will now examine two or three other books of Physics, and first that of Prof. Silliman formerly of Yale College. Mr. Silliman introduces his section on Acoustics as follows:

ACOUSTICS.

1. *Production and Propagation of Sound.*

"**Acoustics.—Sound.**—Acoustics teaches the science of sounds, their cause, nature and phenomena. Sound, is the impression produced on the sense of hearing by the vibration of sonorous bodies. These vibrations are transmitted to the ear by the surrounding medium, which is ordinarily the atmospheric air.

"**Sound a sensation.**—It will be understood, therefore, that all sound, whether unmusical, like mere noise, or musical, like what is technically called a *tone* (a sound of definite and appreciable pitch), is a *sensation;* and the causes which produce this sensation may exist without the sensation itself—that is, without sound. The cause of sound being atmospheric vibration, if there be no delicately constructed organ, like the ear, to receive the impression of this vibration, there is no sound. It would follow, that even at the Falls of Niagara, if there was no ear present to receive the impression, those gigantic vibrations, would exist only as such—without sound."

The first sentence says that acoustics teaches the science of sounds, their cause, nature and phenomena.

Substituting for sounds in this sentence its definition in the next, we have:

Acoustics teaches the science of the impression produced on the sense of hearing by the vibrations of sonorous bodies.

Webster says:

"**Acoustics.**—*n. sing* [fr. *Acoustique*]. The science of sounds, teaching their nature phenomena and laws.

"This science is, by some writers, divided into *diacoustics* which explains the properties of sounds, coming directly from the sonorous body to the ear; and *catacoustics*, which treats of reflected sounds."

Transposing again, Webster's definition of Acoustics becomes:

"The Science of the impressions produced in the sense of hearing by vibrations of sonorous bodies, teaching their nature, phenomena and laws:

"This science is by some writers divided into *diacoustics*, which explains the properties of the impressions produced upon the sense of hearing by the vibrations of sonorous bodies, coming directly from the sonorous body to the ear; and *catacoustics*, which treats of reflected impressions produced on the sense of hearing by the vibrations of sonorous bodies."

This certainly is a little mixed.

Book V. of Ganot begins:

ACOUSTICS.

Production, Propagation and Reflection of Sound.

219. "Sound is a peculiar sensation excited in the organ of hearing by the vibratory motion of bodies, when the motion is transmitted to the ear through an elastic medium."

222. "Sound is also propagated in liquids. When two bodies strike against each other under water the shock is directly heard."

Substituting for Sound in 222 the definition given in 219 we have:

"The peculiar sensation excited in the organ of hearing by the vibratory motion of bodies, when this motion is transmitted to the ear through an elastic medium is also propagated in liquids."

This, too, would appear to be considerably complicated.

Making the same substitution in article 224 we have:

"The intensity of the peculiar sensation excited in the organ of hearing by the vibratory motion of bodies when this motion is transmitted to the ear through an elastic medium, is inversely as the square of the distance of the sonorous body from the ear."

Substituting again in article 232, "Velocity of sounds in liquids and in solids," we have:

"The velocity of the peculiar sensation excited in the organ of hearing by the vibratory motion of bodies when this motion is transmitted to the ear through an elastic medium, in water, was investigated in 1827, by Colladon & Sturm and found to be 4708 feet in a second at the temperature 81°, or four times as great as in air."

It begins to appear that the definitions of Sound given by either Mr. Silliman or Ganot at the beginning of their essay will not hold water. And this will become more and more evident as we proceed. It would be very difficult to reflect, or refract the peculiar sensation excited in the organ of hearing etc., as Sound is defined by Mr. Ganot; or, "The impression produced on the sense of hearing by the vibration of sonorous bodies," as defined by Mr. Silliman.

And it is evident that Sound, in all ordinary or correct use of the word, has nothing to do with any sensation in the organ of hearing, except to make it.

This double definition of Sound is a gross blunder. To illustrate its absurdity, we will suppose the vibrations referred to, to be those of a tuning-fork. This sentence might then read, "Sound is the impression produced on the sense of hearing by the vibrations of a tuning fork. These vibrations are transmitted to the ear by the surrounding medium, etc."

What is meant by these vibrations? The particular vibrations of the tuning-fork certainly are not transmitted to the ear, nor, according to the undulatory theory, are there any similar vibrations of air transmitted, if that was what was meant. For the vibrations of the fork are veritable vibrations to and fro with quite a limited extension that decreases with absolute regularity in each direction till it stops.

But the hypothetical air waves selected by the scientists to represent these have various length, as the text-books tell us, from a few inches, more or less, to over 1100 feet. Thus in air,

a C.–3 fork is 70 feet
which in C.–2 " 35 "

In certain other substances this would be increased over 16 times.

Waves of this magnitude supposing them to exist, have no resemblance whatever to the vibration of a tuning-fork, and therefore not only are the vibrations of the fork not transmitted, but nothing in the slightest resembling them.

Probably no philosopher ever placed a more ridiculous statement in a book, than that of Mr. Silliman's that if there was no ear there would be no Sound. This difficulty is in the definition of the word Sound; in trying to make it conform to the inconceivably stupid so-called air wave or undulatory theory.

The thing which Mr. Silliman defines as Sound is the sensation of hearing, which is not Sound but caused by Sound. The word Sound has already been preëmpted to mean that which produces the sensation of hearing, and no one is justified to assume for it any different meaning. Driven to apply the word to hypothetical air waves, something self-evidently impossible, a custom has sprung up of using it for the sensation of hearing, which simply makes a bad matter worse.

Sound is the substance designed by the laws of God to affect mind so as to produce the sensation of hearing. It is made by shock or collision of bodies, and consists of infinitesimal particles of electrical matter, which being endowed with a principle of motion, dissipate in the atmosphere somewhat similar to a mist or cloud, only they are invisible, and entering the ears of all animals in their path are thus transmitted to the mind through machinery of the interior ear, acting by the principle of unison vibration.

We have spoken of mist or cloud because the whole atmosphere is pervaded with Sound,—every sound. And yet each individual sound, we presume, moves in straight lines.

The sound is not a sensation but the cause of one. It doesn't depend in the slightest upon the existence of any ear, although it is intended to be correlated by an ear, and would be useless without one.

"Full many a flower is born to blush unseen
And waste its sweetness on the desert air."

But though Mr. Silliman dulled in introducing a second definition of sound entirely opposed to its usual one, the first paragraph in his book is one of the best definitions of matter, if not the best, we have ever seen, brief, accurate, and complete, and indeed the whole Introduction of the book, of which this is the beginning, is a marvel of sincere and accurate perception, so much so that we will conclude this chapter with its insertion.

1. "**Matter.**—Matter is that which occupies space and is the object of sense. Our knowledge of the material world is founded upon experience, or the evidence of our senses; and the conviction that the same causes will always produce the same effects.

"A definite and limited portion of matter, whether it be a particle of dust or a planet, is called a *body*. The different kinds of matter, as water, marble gold, or diamond, are called *substances*. Numberless as are the various substances known to man, they are all composed of a limited number of simple bodies called *elements*.

2. "**Observation and experiment.**—By observation we become acquainted with those changes, in the condition and relations of bodies, which occur spontaneously in the ordinary course of nature; but the knowledge thus acquired is limited when compared with the results of *experiment*. By use of proper apparatus we can repeat natural phenomena under varied conditions; and, among all the attendant circumstances, we can determine what are accidental, and what are essential to any given effect.

"**Phenomena.**—A phenomenon, in the sense in which this word is used in science, is any event taking place in the ordinary course of nature. Thus the changes of the seasons, the fall of rain or dew, the burning of a fire, and the death of an animal, are more truly phenomena of nature than those more rare or alarming events to which in a vulgar sense this word is usually confined."

3. "**Law, Theory, and Hypothesis.**—In conducting an experiment, we are taught to trace with certainty the *connection* between different phenomena; to classify effects of the same kind and refer them to their common cause; in fine, to deduce from many experiments the governing principle, or *law of nature,* in obedience to which they are produced, and to unite both facts and principles into a *theory,* or comprehensive view of the whole subject. Such theories are a fruitful source of new experiments and new discoveries.

"The terms *law, theory,* and *hypothesis* are often used interchangeably, and are all designed to express the various degrees of perfection attained in any department of human knowledge, towards the understanding of the thoughts of God as expressed in the phenomena of the physical world. An *hypothesis* is a guess or assumption, designed to aid further investigation, and bears the same relation to a theory or law as the scaffolding bears to the perfect building. A theory is the most perfect expression of physical truth, and is deduced from both laws and principles that have been established on independent testimony.

"That a theory should rise to the highest expression of the laws of nature, it must account not only for all known phenomena falling under it, but for all possible cases with irregularities and variations. Thus the law of gravitation, as developed by Newton from terrestrial phenomena, has been found strictly universal in its application; not only meeting all known facts in celestial mechanics, but, outstripping observation, it has foretold events which have been subsequently confirmed, or which it still requires centuries of years to verify."

4. "**Inductive Philosophy.**—When the individual experience is enlarged by the experience of other inquirers and other times, and the combined knowledge of many is so arranged as to be comprehended by one, the system becomes a *science* or philosophy of nature. Because its

principles are founded upon a comparison and analysis of facts, a system of this kind is also called *Inductive* Philosophy.

"Inductive philosophy is of modern origin. Galileo (born in 1564) was the first to commence a course of experimental researches; and Bacon (born 1561), in his immortal work, *Novum Organum*, showed that this was the only road to an accurate knowledge of nature. The ancients were ignorant of the principles and methods of inductive science. Their explanations of natural phenomena were based on *assumed* causes; they are therefore confused and contradictory, and often in direct opposition to experience.

5. "**Force.**—From the axiom that every event must have a cause, the mind naturally passes to the recognition of certain powers or *forces* in nature adequate to account for the observed phenomena. Thus we refer the fall of bodies to the earth to the force of gravitation—the strength of materials to the force of cohesive attraction—the directive power of the compass-needle to the earth's magnetism—the evaporation of water to the action of heat—the combustion of a fire to the action of oxygen on the elements of the fuel, or the force of chemical affinity.

"Man exercising his volition walks, or strikes a blow—examples of the mysterious connection between spirit and matter, of the conscious exercise of mechanical force. By the use of a lever or screw he transmits or multiplies his force at will—by experiment he learns that he can also, by suitable appliances, call into action, where he pleases, certain other forces, otherwise dormant, which he calls *chemical*, or *physical*, according as they do, or do not, involve an essential change in the nature of the materials employed. Both his consciousness and experience inform him that all these manifestations of force result from the voluntary but mysterious action of mind upon matter. He is thus led to the unavoidable conclusion that those great phenomena of nature, over which he has no control, must have their origin also in the volitions of a SUPREME RULER. FORCE and WILL thus become related terms, and we are compelled to regard the forces of nature, as they are usually styled, as only the outward and visible manifestations of the mind of God.

"In Physics the term force is often used for the unknown cause of a known effect.

6. "**The properties of matter are general, or specific.**—The attentive consideration of any sort of matter will show us the existence of two sorts of properties in it—namely, general properties and specific properties. Gold, for example, occupies space and possesses weight, but so also does all matter, whether solid, liquid, or gaseous; these properties are *general.* But gold has a peculiar color and lustre, is unchangeable by the action of causes which destroy the identity of nearly all other sorts of matter, has a definite and peculiar crystalline form, and weighs about nineteen times as much as a like bulk of water. These are qualities peculiar to gold, and by which we always recognize it. They are its *specific properties.*

7. "**The changes in matter are physical, or chemical.**—Water is changed by heat to steam or vapor,by loss of heat (cold) it is reduced to a solid. By the ceaseless action of these natural causes, it perpetually changes its place and condition. It returns to the earth, from its distillation in the great alembic of the atmosphere, as dew, mist, rain, hail, or snow, and by gravity seeks to gain a place of rest in the great ocean. But in all its changes of state and position it is still the same substance. A bar of iron, by contact with a lodestone, acquires new properties, which we call magnetic, but its color, form, and weight remain unchanged. A glass tube or plate of resin rubbed by dry silk or fur becomes electrical, in virtue of which property it will attract or repel light bodies. These changes, which do not destroy the specific identity of the substance, are termed *physical changes.*

"But in a damp atmosphere the iron bar is soon covered with rust, from the action of oxygen (one of the gases of the air) upon the iron. The same change follows the action of water alone. In this latter case the water is decomposed, and with great activity if a dilute acid is present. The oxygen of the water combines with the iron, while the hydrogen escapes as a gas, and thus the *specific identity* of both substances is destroyed. Such changes, destructive of *specific identity*, are called *chemical changes*.

8. "**Physical and chemical properties of matter.**—The changes of matter just noticed correspond to its physical and chemical properties. Gold possesses certain specific properties, depending solely on its physical qualities; its density, lustre, color, form, malleability, and its high point of fusion, are all qualities of gold which can never be lost without an essential change of its nature, and are therefore termed physical properties. Exposed however to the action of chlorine and certain other agents, gold loses its specific identity, and becomes, as it were, a new substance, while the same change passes equally upon the agent by whose efficiency the transmutation is effected. Such changes of matter, involving an essential loss of specific identity, depend on the *chemical properties* of matter.

9. **Physics and Chemistry.**—It is plain that the distinctions just pointed out are fundamental, in the nature of things, and that out of them spring two entirely distinct, although nearly related, branches of human knowledge, namely PHYSICS and CHEMISTRY; the former is more frequently called, in this country *Natural Philosophy;* a term too comprehensive in its general significance for an exact definition. Now as all substances possess both physical and chemical properties, it is plain that a thorough knowledge of either branch involves some familiarity with the other. But the natural order of knowledge consists in obtaining first a familiarity with the general properties and laws of matter, and subsequently the specific properties. Physical knowledge therefore naturally precedes chemical.

10. **Vitality,** or the principle of life, is recognized as a distinct force in nature, controlling both physical and chemical forces; by its

action inanimate or unorganized matter is transformed into animate and organized existences. Thus, out of air, water, and a few mineral substances, all living forms, both animal and vegetable, are built up by the chemistry of life. After a life of definite duration, they die, and their structures dissolve again into the inanimate bodies out of which they grew. They are subject to the general laws of matter, but these laws are often modified, and sometimes directly opposed by the action of that unknown power which we call the *principle of life*. The description of organized bodies constitutes the science of Natural History."

XVI.

IT is very evident that this thing Sound is so closely connected with shock or disturbance as in some way to act as a picture or copy of it. It stays with it from start to finish, waits upon it and carries its messages, eclipsing all other travelers, at least ordinary ones, upon the same routes. And its routes are in all directions.

Nor does it linger, but attends strictly to its duties until its messages are delivered, or until its three score years and ten being accomplished it falters in its path, and, its mission ended, dies. It is also evident that this copy, in whatever it may consist, is in some way transmitted through the air, entering the ear, any ear, as naturally as water enters a brook or river, and thus finds its way to the soul.

Sound is then the copy of a disturbance, but it is evidently a very different phenomenon from vision, or that kind of picture or likeness which is produced upon the retina of the eye by light. And yet in many respects these phenomena are similar.

When it is found that Sound is conveyed by many substances far more swiftly than by air; that it is invisible, and yet shows remarkable action when carried or conducted through solid bodies,—as for instance the rods used by Wheatstone to convey the sounds made by musical instruments, operating in the basement of a building, through the floors to an upper room, where, by aid of a sounding-board, to which the sounds were thus conducted, he was enabled to give a concert,—we realize that Sound is a distinct substance or thing; made in great quantities; that it is invisible though its motion is plainly evident when conducted through many bodies; that it is what we would call infinitely small, although possessing a large amount of strength and action.

As we have elsewhere proven in this book, it is made by shock. It is then corpuscular, composed, as innumerable other things of different sizes, from matter, undoubtedly by the usual law of its combination in different conditions and proportions; one of these combining properties being motion.

And it would appear that this power to recreate bodies, which will repeat sounds similar to themselves, depends upon the peculiar motion with which every sound is endowed.

Because of this, given a substance in which it can impress its form in an enduring mould, new sounds therein, produced by shock, will duplicate those creating them. Under this rule there could be no sounds excepting similar sounds were previously made.

The more remarkable part of this phenomenon are the methods, as yet unknown, by which it reflects a disturbance, and affects the soul.

Why should the same sound always suggest the same disturbance or cause? Often a person is recognized by his voice as quickly as, or quicker than, by his face. And the principle is general that anything which produces a sound, will, other things being equal, always produce a similar sound.

But this is a universal principle—the same cause, the same effect; or, the same effect, the same cause.

What is the cause and what the effect?

A picture can be reduplicated by light and repeatedly so with a proper surface to reflect it.

It would appear that Sound can be, if in any way a body is found having unison vibration with the body which made the sound. In such case, called consonance, there is no shock. Again, Sound may be repeated, as in a graphophone record; in this case shock—that of a reproducer—is necessary.

It is certain that the sound, any sound, the same as any odor, would be repeated, if precisely the same particles of matter which composed the first sounds could be repeated. And it is certain that these could be repeated by the same body that made them, and therefore by any precisely similar body.

In the case of the graphophone record we know it is not a precisely similar body; and, therefore some body not precisely similar must be able to make precisely similar sounds, or very nearly so.

And therefore, again, a whole body, that is, a body as a whole, is not engaged in the making of Sound, and possibly some parts of the body which are used might be supplied by other similar parts.

In making lemonade the essential parts are the lemon, sugar and water. The glass or pitcher that it is mixed in, or spoon or ladle that stirs it, might be equally well supplied by other utensils.

What then are the essential parts in the manufacture of sounds?

Always first is shock, or disturbance. And this is always followed immediately in a musical instrument by the oscillatory motion, more or less evident, of the body struck.

In most cases this Sound, as we have said, is instantly dissipated, the whole of it starting at once in its course through the atmosphere. That is, most bodies are not musical instruments; have no arrangements for holding, and therefore are not able to hold, a supply of Sound, to be furnished as thought best, or as wanted. This is what every musical instrument to a greater or less extent can do, and what any other body except a musical instrument cannot do. The average body when struck utters its normal sound at once, which generally, if not always, is a pretty plain one. Musical instruments, with their different methods of producing and delivering sounds, are enabled to provide that assortment so useful and agreeable in the economy of nature, and to these are supplemented that other assortment which comes from incessant movement, as the melody of mountain streams, roar of the ocean, lakes, and waterfalls, whistling and sighing of the winds, pattering of raindrops, and the more vigorous music of storms.

It would appear to be proven that Sound, whether made from the original cause of disturbance, or by the record of the graphophone, is composed of material existing in air, and most probably, like odors, of carbon, hydrogen and oxygen, with a certain amount of electricity. Its electrical character was demonstrated by Oersted nearly a hundred years ago.

Exactly how the graphophone record is made, we do not know. We do know that it is made directly or indirectly by Sound, the particular sounds made or spoken into the megaphone, which connects through a diafram with the recorder; this recorder having a small cutting instrument of glass fastened to it, whose end rests upon the paraffin and wax which covers the revolving cylinder.

It is suggested in "Ellen," that the record is made directly by the particles of sound, spoken into the instrument, passing through the diafram, thence conducted to the glass point, and entering the groove, when cut by the recorder, and making an exact impression of themselves in the paraffin and wax. In this case the particles of sound would drop into the cut groove quite as seed are sown into a row made by a hoe.

This explanation was made especially to avoid the difficulty of several different indentures apparently being made at the same time, by the same instrument.

The law of resultants certainly is not superceded; but Sound is a very active agent, fully sustaining its reputation of being electrical, and it may be quite possible that it moves quickly enough to make the cutting instrument indent the different indentures which appear, consecutively. This question of exactly how it is made does not affect in the slightest the fact that Sound is corpuscular.

XVII.

GANOT thus refers to the ear trumpet.

"**Speaking trumpet. Ear trumpet.**—These instruments depend on the reflection of sound in tubes.

"The *speaking trumpet*, as its name implies, is used to render the voice audible at great distances, more especially on board ship. It consists of a slightly conical tin or brass tube, fig. 21, very much wider at one end (which is called the *bell)*, and provided with a mouthpiece at the other. They are as much as seven feet in length, the bell being one foot in diameter.

Fig. 21.

"The larger the dimensions of this instrument the greater is the distance at which the voice is heard. Its action is usually ascribed to the successive reflections of sound-waves from the sides of the tube, by which the waves tend more and more to pass in a direction parallel to the axis of the instrument. It has, however, been objected to this explanation that the sounds emitted by the speaking trumpet are not stronger solely in the direction of the axis, but in all directions; that the bell would not tend to produce parallelism in the sound-wave, whereas it certainly exerts considerable influence in strengthening the sound. According to Hassenfratz, the bell acts by causing a large mass of air to be set in consonant vibration before it begins to be diffused. This is probably also the reason why sound travels best in the chief direction of the sounding body; thus the report of a cannon, the sound of a wind instrument in the line of the tube, the voice of the direction of the mouth, &c.

"The *ear trumpet* is used by persons who are hard of hearing. It is essentially an inverted speaking trumpet, and consists of a conical metallic tube, one of whose ends, terminating in a *bell*, receives the sound, while the other end is introduced into the ear. This instrument is the reverse of the speaking trumpet. The bell serves as a mouthpiece; that is, it receives the sound coming from the mouth of the person who speaks. These sounds are transmitted by a series of reflections to the interior of the trumpet, so that the waves, which would become greatly diffused, are concentrated on the ear, and produce a far greater effect than divergent waves would have done."

Perhaps no passages in this book show how entirely it was written to supply the market,—that is, written to sell,—so strongly as this. For we cannot but feel that Ganot was too able a man to be fooled by the suggestions which he quotes from others, as explanatory of these instruments. The statement concerning the ear trumpet is absolutely false.

Chambers' Encyclopædia under Speaking Trumpet, says:

"**Speaking Trumpet.**—An instrument for giving concentration, rather than dispersion to the waves of sound originated by the articulation of the human voice, and thereby enabling the sound to be conveyed to a greater distance. It is of the utmost use on shipboard in enabling the officers to convey orders during windy weather from one part of the deck to another, or to the rigging. The invention is ascribed to Sir Samuel Morland, in 1670, though Athanasius Kircher laid claim to it. Morland's trumpet was of the same form as that now in use—viz., a truncated cone, with an outward curve or lip at the opening.

"The theory of the action of this instrument has never been thoroughly explained; but it is supposed that the sides of the tube throw the sound back and back in various reflections, until ultimately the waves quit the instrument in parallel lines. It does not seem to depend on vibration of the instrument."

Of the Ear Trumpet this Encyclopædia says:

> "A contrivance for improving the hearing of the partially deaf. For this purpose many ingenious instruments have been devised. The principle in them all is the same: to collect the sonorous vibrations, and to convey them in an intensified form to the deeper parts of the ear."

This is the usual parrot like talk, intended to conceal ignorance, but wholly without meaning.

Ganot says:

> "The wave length of the sounds emitted by a man's voice in ordinary conversation is from 8 feet to 12 feet, and that of a woman's voice is from 2 feet to 4 feet."

And these we suppose to be what are called sonorous vibrations. And as they are spoken by individuals, and couldn't have such length in the throat, it is assumed that something of this kind varying from 2 to 12 feet in length, according to sex, and carrying the correlative of Sound are hovering about in the air, and can be introduced into the ear trumpet, scarcely a foot in length.

It would of course be impossible to get such waves with their form unharmed, as it would have to be if representing the sound into an ear trumpet, if they existed, but they don't exist.

The whole thing is too absurd for further consideration. There isn't the slightest scintilla of truth in any part of it.

Professor Silliman says:

> "**Ear-trumpet.**—The hearing-trumpet, intended to assist persons hard of hearing, is in form and application the reverse of the speaking-trumpet, although in principle the same. It consists of a conical tube, turned in any convenient direction, so that the opening, may enter the ear. The strengthening of the sound by this instrument was formerly attributed to reflection of sonorous waves caused to converge to the ear, and it was sought to obtain the form most favorable to fulfill this condition; thus the cone was replaced by a paraboloid, having its focus at the point. But these different forms have no effect upon the result. Moreover, the nature of the walls, and the condition of the interior surface, whether rough or polished, or lined with cloth, has no effect upon the intensity of the sound. The only essential condition is that the exterior opening should be greater than that which enters the ear. [That is, that a hopper should be broader at the top than at the bottom.] The effect of the ear-trumpet is explained as follows:—The portions of compressed or dilated air, which arrive at the exterior opening, transmit their compression or dilatation to portions of air smaller and smaller, and consequently transmit it with increasing intensity. In this manner the portion of air at the point receives and transmits to the membrane of the tympanum a compression or dilatation of much greater intensity than in the absence of the instrument. Holding the hand concave behind the ear, as deaf persons are seen to do, concentrates sound in the manner of an ear-trumpet. The form of the external ear in animals favors the collection of sound.

Here the reflection of sonorous waves is given up, and another explanation equally absurd, impossible and inexcusable, introduced. The key to the whole situation, "that the only essential condition is that the exterior opening should be greater than that which enters the ear," is mentioned, but, though trumpet-tongued, is dismissed by those who are tongue-tied by authority.

The sense of hearing is defective. But Sound is that which makes the sense of hearing possible. The ear-trumpet is introduced to test the universal law of nature—true to a certain extent in some things, and to any extent in others, that effects are proportionate to amounts. If a little Sound fails to make one hear, perhaps more will succeed.

A thimble full of water or a gill is something to a thirsty man, but a quart is far more effective. The same is true with things to appease hunger, or in clothing for warmth.

A few bricks or any other material will build a small building, more a much larger one. A few particles of light may suggest vision, plenty of them make it certain.

This law may be illustrated indefinitely. You can't go amiss on it, and you don't in this matter of Sound. It is the one method, other things being equal, by which nature regulates want and supply. We know that very few scientists appear to know this; at least very few seem to apply it in their teaching, or reasoning, if they take the trouble to reason. But it is one of those principles which may safely always be drawn upon to assist us in trying to discover hidden principles in nature, and will often help out, as this does here.

If Sound is a solid substance like grain, although it may be indefinitely finer than grass or clover seed, the increased opening of the ear-trumpet will gather more of it, and the tube tumble it down into the ear, when immediately the person that was deaf hears better, if the trouble is not too serious, and perhaps perfectly.

And for no other possible reason, excepting that the thing made by God to operate upon the sense of hearing, is able sometimes to do so if supplied artificially in larger amounts, when it could not do it otherwise.

In this respect it resembles the operation of the kindred sensation, vision, which by the aid of glasses of different kinds, is able to converge to the eye an increased number of particles of light, and thus enable one to see, where he could not before. In each case this is accomplished by increasing artificially the supply of Light and Sound, for the purpose of sight and hearing, by instruments which cause the different streams of these particles in the air to converge to the eye and ear.

It is a similar thing to arranging artificially that a number of streams of water should converge or empty into the same pond, and thus furnish a needed supply; and in each case these streams are combinations of matter, and could be nothing else. For there is nothing else in the universe to make them of.

XVIII.

STILL another book of Physics we find in our library in which persistent effort is made to explain the phenomena of Sound by accepted theories. It is of course a dismal failure, though perhaps it would be impossible to make a better attempt. We refer to Elements of Physics or Natural Philosophy by Neil Arnott. Tenth edition, edited by Alexander Bain, 1879. The first edition was published by the author in 1827. Mr. Arnott was born in 1788 at Arbroath in Scotland, died 1874.

The consideration of Sound begins on page 305, as follows:

> "SOUND *is heard when some sudden shock or impulse occurs in any body having communication, through the air, or otherwise, with the ear.*"

This is a strictly correct statement and Mr. Arnott certainly deserves credit to have gone straight so far. The book is free of the nonsense referred to by the Yale College book, and of the misstatement made by Ganot, although the latter had condoned for this in advance by a very conspicuous notice that the whole subject was "completely unknown." The remaining four specifications relating to Sound are very cautiously stated, and with a little latitude in interpreting words, fairly correct; that is, not grossly incorrect.

The book proceeds with a brief statement of the origin of the undulatory theory. It says:

> "Because all bodies around us are immersed, in common with our-

selves, in the ocean of air which envelopes the earth, we are much more frequently warned of these shocks and tremblings by their effect on the air than in any other way; hence the early conclusion that air was necessary to sound, and hence, in part, the reason why the study of sound was formerly included in that of *Pneumatics*. It is now known, however, that all bodies are more or less fitted to convey sound, and that air in many cases is neither the quickest nor the best conductor."

Unquestionably this theory would never have been suggested had it been first known that Sound went through many bodies both faster and further than in air.

Mr. Arnott repeats the statement that "The report of a pistol is not nearly so loud in the thin air on a lofty mountain top as at the base of the mountain, and that human voices are remarkably weakened;" and adds: "On the other hand, in the condensed air of a diving bell a whisper is loud."

The book then undertakes to illustrate the action of a vibrating body to produce an air pulse of continued length, something absolutely impossible because of the mobility of the air.

It next introduces an explosion as Sound, as follows:

"A striking illustration of the power of air to transmit such mechanical impulses is seen in the explosion of a magazine. The shock is sufficient to break windows and shatter houses at a considerable distance from the spot.

"In the explosion of five tons of gunpowder which took place in October, 1874, on Regent's Canal, traversing the Regent's Park, the injury done by concussion and vibration was of enormous extent. It was reported that more than a thousand houses in the north-west of London had been damaged more or less in this catastrophe. Major Majendie states that the area of structural damage to houses extended to a distance of four hundred yards from the seat of explosion under the Canal bridge, and the area of damage to window-frames, sashes, ceilings, and doors extended to six hundred yards. The area of broken windows reached from three-quarters of a mile to one mile, and the area within which the shock or sound is known from reliable evidence to have been sensible, was fifteen miles (Waltham Abbey). The concussion at two and three miles distance was very violent, and one death, produced by the shock and alarm occurred at two miles (Holloway).*

"In those cases in which the windows were open, the glass for the most part was not broken.

"All sounds of great intensity such as those of thunder and the discharge of heavy artillery, produce sonorous waves of such force as to break and destroy glass and other brittle objects. This is simply the result of a sudden and violent concussion of the air.

"On the other hand, the aërial concussions which accompany feeble sounds may be revealed and beautifully illustrated by their action on flame."

The above is an illustration, so far as we know held by all text-books, that the destruction caused by explosion of all kinds, is done by Sound, when they ought to know—do know—that Sound is phenomenally harmless, no matter how extensive it is. It won't put out or make duck the light of a candle or lamp, unless of unison vibration with it. In a thunder storm, the lightning may kill, but the thunder never injures, though when having the same vibration it may make a pane of glass rattle.

We admit if Sound was air waves it ought to destroy things, going as it does, and as every text-book teaches, over 700 miles an hour, whilst the greatest hurricane or tornado goes but a little, if any, over 100 miles. If it was air waves, there would soon be nobody to hear it, in fact there would be nothing else on the earth, or in the material universe. Very fortunately the scientists are not permitted to experiment with any of their theories.

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* Report on the Explosion of Gunpowder in the Regent's Park, 1875, p. 10.

Living much of the time upon the Green Mountains, 1500 feet above the sea, where, during a south-east storm, blowing straight from the Atlantic, the air pulses are unusually lively, I have myself had considerable experience with them. A number of barns near me have been blown down, timbers from one of them having been carried with such force as to break through the clapboard partition into my dining room.

At another time, the sound waves were seen approaching from the high hill south, where they made themselves known by overthrowing quite a number of the hemlocks and spruces averaging about 75 feet in height.

At the time these sound waves were approaching, a meeting was being held in the school-house. The waves lifted this up and set it down at right angles, whilst a boy on the road was taken by one of them and unceremoniously dropped in a neighboring field. The same was done with a carriage, by a number of the waves though the horse, liberating himself, kept his place on the highway.

It must be evident to every one that the board carried by the wind into the dining-room was not Sound, but a solid extended substance capable, when hurled against a partition, of breaking through it, whch no sound that ever existed could do. It is equally plain that particles of air are as much a substance as the board, and when massed and moved with sufficient force may be very destructive. But they are no more Sound than the board is Sound. It would be utterly impossible for them to move with the speed of Sound. The roar or sound of the above tornado, as always in such cases, preceded the storm by quite an interval of time; and was, too, harmless, as shadows or light. Indeed, pictures, whether by Sound or Light, of disturbance or rest, are equally harmless, their functions being to educate, not to destroy; although, again, it is true that the disturbance which is thus distinctly copied may be destructive; and so the subject of many a picture may be destructive.

An explosion brings an entirely new force into action, that of the gases engendered by it. The pulses of air, too, are aroused, whilst at the same time a large amount of Sound is made. The air pulses and gases, one or both, are responsible for the breakages, and with the breakages comes more Sound, but the sound is one thing and the gases and air, thrown off by the explosion, two other and very different things. Harmlessly the sounds spread in all directions, doing no damage but giving warning of the approaching catastrophe. The roar of a storm is heard for miles beyond its course. And so the coming of the rain and wind is heard for some little time before it arrives. All this proves that the two things, air pulses and Sound, are entirely different.

Frequently at Middlebury, south-east storms in winter are heard upon the mountains in Ripton, ten and twelve miles off, whilst everything is quiet in the Champlain valley below, excepting the roar of the distant storm. That these and their roar, or noise, are entirely distinct may here be most fully perceived. The last is manufactured by the usual disturbance, or shock, produced by the storm, and spreads through the atmosphere in all directions. The roar of Niagara is not Niagara, but the acoustic picture of it. And so the roar of a storm is not the storm but the acoustic picture of it. From below the mountains where only the sound was heard of the storm above, we have ridden on horse-back in mid-winter into the wind, sleet, and snow, which grew stronger and stronger as we reached the higher table-lands that, between the first and second range, extend many miles north and south. Thus the sound and the storm are two very different things; and so the sound and explosions are, as every one knows who knows anything at all about the subject. And when one finds them spoken of as the same, he sees how hopeless it is to expect correct information upon such subjects, from such source. And still, so far as we know, all text-books, and many if not all instructors, confuse the two.

XIX.

THE action of sensitive flames is next considered, which we have fully explained by the corpuscular theory. This book, although making some bold statements about their being the effect of sonorous vibrations, admits further on that their cause is wholly unknown. As both the experiments mentioned and the discussion of them are unusually interesting, we copy in full.

Effect of vibrations on flames,—Sensitive Flames:

"Flame, or the combustion of light and highly volatile matter in a visible form, is admirably adapted to show the existence of feeble currents of air, and it has proved equally serviceable in establishing the existence of vibratory movements of the air as the result of sound when all other methods have failed.

"When coal gas is burnt out of a small orifice, V shaped and under sufficient pressure, a taping flame about fifteen inches in length is obtained. Mr. Barrett found that the shape and character of the flame underwent some remarkable changes when sounds were produced near it. On clapping the hands, or tapping the table, the tall quivering flame shrank down nearly half its height, spread out laterally into a wider or fish-tail flame, and an increased amount of light. On the cessation of the sound, the flame again rose to its original height. He was thus able to fire gunpowder or gun-cotton by producing sound at a distance from the flame. The sound produced by the gentlest tap, and not mere loudness, the chinking of money, the shaking of a bunch of keys, the creaking of boots, the crackling of a fire, the dropping of a cinder, the ticking of a watch, and even the splashing of a rain-drop—all of these sounds startled or convulsed the flame, and the crumpling of tracing-paper or the rumpling of a silk dress, caused it, as Mr. Barrett describes, to become frantic with commotion. We have therefore in this kind of flame a wonderfully delicate test of the vibratory motions in the air which produce sound.

"These remarkable changes in the flame are due simply to the effect of sonorous vibrations, and not the concussion of the displaced air which attends the original production of the sound. A stroke on the C above the treble of the piano produced just the same effect as the clapping of the hands. It is, in fact, as Mr. Barrett has stated, the product of translated *motion*, and not of translated *matter*. It is the result of those undulations of the air by which sound is propagated. The facts, too, illustrate the velocity with which sound is propagated, for the movement of the flame is simultaneous with the hearing of the sound, whether near or distant, so long as it can be heard.

"If a man whistles near such a flame it instantly responds, and is lowered as described. If he leaves the room, and shuts the doors, the flame still responds to the whistle outside, in spite of this obstacle to the passage of the vibrations. This shows how small an amount of vibratory motion in the atmosphere may be rendered evident by a sensitive flame. At thirty or forty feet distance, a sensible effect was produced by sound on the flame, and considering that the vibratory movements are inversely proportional to the square of the distance, the amount of motion by which it was affected must have been infinitesimally small.

"This kind of flame is not equally sensitive to all sounds. Thus the bass notes of a pianoforte did not disturb it, but as the high notes were approached, the flame became uneasy and its shape was changed. In reference to speech, it was found to be remarkably sensitive to sibilants; thus such words as hiss, hush, and brush caused it to be instantly lowered; and, according to Mr. Barrett, even 'if you go away and out of sight the flame will shiver all over every time you utter the obnoxious sibilant.' It is only the high notes of a violin which affect it; but it dances to the music in perfect time when a tune is played to it on any musical instrument. In an experiment performed at the Royal Institution, Professor Tyndall caused the flame to dance to the tune played by a musical box. When spoken to, or verses were recited near it, the flame underwent a variety of changes, moving up and down, widening and contracting itself according to the nature of the sounds.

"The remarkable effects produced on flame by those vibratory movements of the air, on which sound depends, have not yet received a satisfactory explanation. There is a mystery about them which no philosopher has yet been able to fathom. It is impossible to witness them without a profound feeling of wonder. The results are more like the effects attributed to magic than those obtained by philosophical research. As Mr. Barrett remarks, "We are surrounded by wonders and enveloped in mystery, and at present science can do little more than reveal these wonders, classify these mysterious facts, and awaken a right and intelligent appreciation of them."

With our discussion of the cause of sympathetic vibration this whole mystery is removed. These actions and all similar ones are simply and entirely the carrying out of this principle. That is, the slightest sound, as well as the loudest, consists of infinitesimal particles of matter produced by shock or friction. These are electrical, and all contain within themselves the power of movement, and, whatever the particular disturbance which makes them, they move, so long as they exist, in many different directions, and, whilst in the same medium, at the same speed.

Their duration depends upon their size, and that depends upon the amount of disturbance which makes them. In circulating, should they meet any body having the same normal vibration as the body in which they were produced, and by which they are formed, they will enter it; perhaps are drawn in by some force, as water is by gravitation into the beds of streams, rivers or rivulets, ponds or oceans.

And thus the corpuscles enter the different flames, causing them to vibrate, as we think, simply by circulating through their interstices. In any case they make them vibrate in precisely the same way that they do the body in which they originate, and therefore are their bodies said to have the same or unison vibration, and, as we have said before, this is a peculiar and most important principle of Sound, of which it makes constant use, and through which it finally influences the mind.

Mr. Arnott says further:

> "Instances of sound carried by air have been given already: as further examples, we may cite the cases of what are called *sympathetic sounds*. Most elastic solids, when of certain shapes, being sonorous, that is to say being fitted to tremble when struck, with a certain frequency of oscillation depending on their weight and shape, if the air around them be made to tremble by any cause, with the velocity which they are fitted to take on or produce, they immediately begin to tremble in unison with the air; and their motion or sound may continue after the original cause of it has ceased. Thus almost any clear tone produced near a pianoforte whose dampers are raised, finds a responsive string, and if bits of paper are placed upon the strings generally, those falling on the strings which in turn can vibrate in unison or as octaves to the sounding body are soon shaken off, while the others re-

main. A harp or guitar, in a room with loud-talking company, is often mingling a note with their conversation. A wine-glass or goblet may be caused to tremble (and if on a table at all inclined, even to fall) by a person sounding, on a violoncello near it, the note accordant to its own.

"Sounding bodies vibrate much more quickly, or have sharper tones, if placed in light hydrogen, than in common air, and more quickly in common air than in any of the heavier gases, because the lighter the surrounding fluid, the less is the resistance to the body moving in it.

"If a bell-glass, suspended, is filled with hydrogen by displacement, and a bell struck violently is suddenly introduced into the gas from below, the sound is almost lost. On bringing it into the air, the clear ringing sound is again perceived, showing how much depends on the density of the aërial medium. If a bell struck in air is plunged into a bell-jar of carbonic acid, a much graver sound is produced. Glass vessels containing hydrogen and carbonic acid emit very different sounds when struck. A glass jar containing carbonic acid, which is half again as heavy as the air, emits a dull heavy sound. This is strongly indicated when the rim of a glass containing effervescing champagne or soda-water is struck by a hard substance. So long as the escape of carbonic acid continues, the sound is dull, as if the glass was cracked. As it escapes, the glass acquires its usual clear ringing sound.

"That water is a good vehicle of sound is proved by the distinctness with which the blows of workers around a diving bell are heard above;—by the fact, well known to sportsmen, that fishes hear very acutely. If a bell was rung under water, and a person was also submersed in water, the sound would be heard by him even better than if both were in the air, but the sound is much graver.*

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* A remarkable exemplification of the power of liquids to transmit mechanical pulses or shocks, analogous to those of air in sound, was given by an explosion of nitro-glycerine off the coast of Oregon in 1874. Vast numbers of fish were caught, either stunned or quite dead for a considerable space round the seat of explosion. Similar effects have also been observed after the firing of "torpedoes" under water.

"Singular noises, heard during the dead of night, and which by the superstitious had been deemed supernatural, have often been eventually discovered to be sounds conveyed by the solid wall of the house from some adjoining building.

"It is easy to ascertain whether a kettle boils by putting one end of a stick or poker on the lid and the other end to the ear; the bubbling of the water then appears as loud as the rattling of a carriage in the street, although another person sitting near does not hear it at all. A slight blow given to a steel poker or a steel triangle, of which one end is held to the ear, produces a sound which is painfully loud

"The readiness with which solids convey sound is illustrated by the fact that a small musical box, while held in the hand, is scarcely audible, but when pressed against a table or a door, it will rival a little harp. The vibration communicated from the box pervades the whole of the wood, and the extended surface of that acting on the air increases the effect. The construction of violins, harps, guitars, &c., and of sounding-boards generally, is governed by the same law. In the dancing-master's *kit* or small fiddle, which he carries in his pocket, there may be the same strings and the same bow as for a violin, but it has very little sound, because the extent of its surface is so small. A piece of metal called a *sourdine*, when fixed upon the bridge of a violin, damps the sound, because it is a dead mass resisting the motion of the elastic wood. The vibrations of a tuning-fork are heard much more distinctly when the end of the tuning-fork is pressed against the teeth, than when it is simply sounded in air.

"A very slight fissure or crack in a solid will break the continuity of the vibrations, and reveal itself by a remarkable change in the sound emitted. A scarcely perceptible fissure in a piece of china or biscuit-ware immediately destroys the usual ringing sound. There is a heavy, dull sound produced when the article is struck, and this is often made a test of the soundness of the article. If the fissure is filled up with cement, cohesion is restored, and with it the original sound. A cracked gold or silver coin is detected by the absence of a ringing metallic sound. The iron tires of the wheels of railway carriages are tested with a hammer. The sound emitted reveals to the experienced ear whether the tire is perfect, or whether there is a flaw in it likely to cause an accident.

" *The Stethescope.*—A useful application, in medicine, of this property of solids is the *stethescope* or *chest inspector*, invented by Dr.

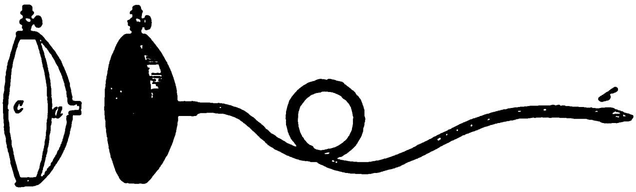

Fig. 22.

Laennec, of Paris. (See fig. 22.) This is a wooden cylinder widening out at one end, which is applied to the chest of the patient while the surgeon places his ear at the other end, and detects any derangement of the working of the inward parts, almost as a watchmaker can detect the deranged beating of a watch. Certain diseases of the heart and lungs, and the degree to which they have advanced, may be clearly distinguished by the aid of this instrument."

XX.

THERE follows, or is interspersed, the usual amount of nonsense about length of waves, etc. That people should make mistakes in science is not at all wonderful, but that these should be persisted in for centuries is most remarkable, and becomes inexcusable.

That the discoveries of Helmholtz in regard to the quality or *timbre* of musical notes are correct, we believe there is no question, but statements that these have anything to do with "wave forms," "aërial masses," or "wave nature," is inexcusable folly when continued, parrot like, for centuries. By a beautiful law as wonderful as that of Light, an infinite God has designed this most useful system of Sound. The atmosphere is its natural road of travel, but it can get aboard many other lines which make much faster time, or go by water both safely and quickly, or entering a telephone wire be carried by the electric current with the speed of light, 184,000 miles a second.

Let the mind's eye follow it. The disturbance which makes it, with perhaps the instruments, or machinery, which assist, are alone visible to the physical eye, but by the universality of natural laws, which by the mind are reflected as in a mirror, we are abundantly able to fathom their secret; for knowing that the kindred sensation of odor consists of infinitesimal particles of matter, wafted by the air to the recipient, we can readily believe and soon demonstrate that Sound is the result of a similar substance.

We perhaps have repeatedly called attention to the fact that one great secret of Sound is sympathetic vibration. It enters all bodies, or may, which have the same vibration as that body in which it was made, and causes them to vibrate. This we think is done because of the nature of their shores; that is, because of the arrangement of their interstices.

As water enters ponds, or finds its level, so will these streams of Sound enter these bodies; and finally by a system of resonators in the interior chamber of the ear, the different sounds are separated and delivered to the soul.

Sounds blossom in quality or *timbre*, as flowers do with many leaves, stamens, and petals, nor can there appear any reason why they should not. The lives of but few of them are over several seconds, it is true, but they are as perfectly made as anything in nature.

We add the following valuable paragraphs from Arnott:

"In solids sound travels more rapidly than in liquids. Its velocity in solids has been estimated 11,280 feet in a second but the velocity is found to vary according to the nature of the solid. Thus, in the metals it is from 4 to 16 times that in air. If the rate of transmission in air is taken as 1, that in gold is 5; in silver and platinum, 8; in copper, 11; in steel wire, 16.

"Biot performed a variety of experiments on the velocity of sound in cast-iron, using for this purpose the water pipes of the city of Paris, which were pipes 3000 feet in length. He found it to be 10½ times greater than in air. In ice sound travels at about the same rate as in water; Chladni found that its velocity was 17 times greater than in air.

The same observer found that in *woods* it was from 10 to 17 times quicker than in air. This shows that it is mere density or closeness of the particles which is the explaining cause. If air = 1, *beech* and *pine* = 10; *ash*, *alder*, *fir*, and *acacia* = 15; and *aspen* = 16. This is the velocity along the fibre, which is in general three or four times greater than that across the fibre; a striking illustration of the difference of physical properties due to mere molecular arrangement.*

"The string of a piano, if its damper be gently raised by touching, not striking, its key, will be heard to vibrate in response to the same note forcibly sung or played near it.

"Bell-shaped glasses can be thrown into violent motion, it is said even shivered, by a very powerful and fine voice singing their proper tone into them or near them.

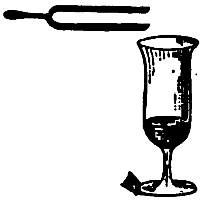

Fig. 23.

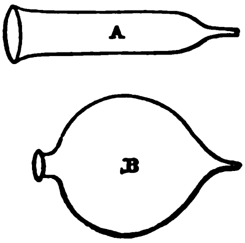

Fig. 24.

"So a tuning-fork at one end of a room will respond to another of the same pitch, struck or sounded by a violin-bow at the other end of the room, but the least difference of pitch destroys this, as may be proved, by fixing a little wax to one of the legs of the resounding-fork. In like manner a stretched india-rubber membrane may be found to answer the note which accords with its natural period of vibration.

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* According to Sir David Brewster sound moves through tin at the rate of 8175 feet and through iron, glass, and some kinds of wood at the rate of 18,530 feet in a second.

"A column of air is an exceedingly sensitive resonator. If a tuning-fork be struck and held over a tall jar, it will be found on slowly pouring in water into the jar that for a certain depth of the water-surface, the tone of the fork is resounded, greatly strengthened, by the jar (see fig. 23). A different pitch of tuning-fork would have a different length of resonant air-column corresponding to it; so that each note has its own resonant air-column which will respond to it when sounded.

"It is an application of this principle that Professor Helmholtz has made use of for the analysis of harmonics. His resonant air masses, or *resonators*, are formed by glass or brass vessels of the shapes A, or B, in fig. 24. They are open at both ends, the smaller end being inserted in the ear. A series of such resonators is constructed so as to resound each to a note of different pitch. It is evident then that, since the inclosed air-column will respond only to a definite note, the corresponding note may be singled out from any mixture of notes and isolated, as effectively as the chemist singles out by precipitation any ingredient he chooses from a mixture of indistinguishable substances. Faint overtones, which would otherwise fail to be distinguished, are thus isolated and their pitch determined. 'The proper tone of the resonator may even be sometimes heard cropping up in the whistling of the wind, the rattling of carriage-wheels, or the splashing of water.' The proper tone of a resonator held to the ear during the playing of a piece of harmonised music, will be heard rising out of the mass in bold contrast.

"By means of a series of such tuned resonators every note of the piano may be analysed or resolved into a number of separate tones; and it will be found that the lower tones are more complex than the higher.

"Also on examining by these means the C sounded on the middle key of the piano, the same C sounded on a plate, a violin, a harmonium, &c., we should find that they all differ in one or more of three respects, namely:—

(1.) 'In the *number* of overtones present; or,

(2.) 'In the *order* of those present; or,

(3.) 'In their *relative intensities.*'

"The possible combinations of harmonics which may thus be created are practically infinite in number. It has been calculated that with six over-tones and two shades of intensity for each, we may thus have more than 400 shades or qualities of tone.

The musical sounds of strings and stringed instruments.

"The rate of vibration in strings increases with their *shortness*, *lightness*, and *tension*: for if a string be *long* or *heavy*, there is a greater mass of matter to be moved than in one short or light, and thence a slower motion; and if a string be slack, the force of elasticity which pulls it from any deviation back to the straight line will be so much the less. The facts are, that a string taken of half the length, or of one-fourth the weight, or of quadruple the tension of another string, vibrates just twice as fast on any one of these accounts; a string of one-third the length, or of one-ninth the weight, or of nine times the tension of another, vibrates three times as fast; and so on for other proportions.

"These truths are familiarly illustrated in the violin. The low or bass string is thick and heavy, being covered with wire, and the others gradually diminish in magnitude and weight, up to the smallest or treble. The strings are tuned to each other by being attached by one end to movable pins, which, when turned, increase or diminish the tension; and the sound produced by each is afterwards varied to a certain extent by the performer pressing different parts of it with the finger against the board, so as to shorten or lengthen the vibrating portion.

"An analogous law, as to the influence upon tone, of weight and dimensions, holds with respect to bells, glasses, reeds, &c.

"If a long musical string be made to sound, and then only half of it be made to sound, as when a movable bridge is placed under the middle, or a finger presses it there, the half will sound the note which is the octave to the first, and will therefore vibrate twice as fast; and similarly the third part sounded, will give the fifth to the last-note, and will vibrate three times as fast as the first; a fourth part, four times as fast; and so on, producing the sounds or tones thus nearly related to each other. Thus, if by means of a bridge we divide the string into two parts whose lengths are in the ratio of any of the notes of the scale, we shall obtain the two notes by sounding the two parts of the string. It was in this way that the ancients discovered the simple numerical ratios connecting the different notes of the scale. The string of a violoncello, when made to vibrate by a bow moved very gently across it, near the bridge, often divides itself spontaneously into two, three, or four, &c., equal vibrating portions, with points of rest between them called *nodes*. When this happens, there are heard in succession, or even together, not only the sound or note belonging to the whole length of the string, but also, more feebly, the subordinate notes belonging to its half, third, or fourth, &c., that is the whole series of *harmonics* as explained above. Often in such a case the subordinate sounds swell with such force as to overpower for a time the fundamental note. The same harmonic sounds may be produced still more certainly, while drawing the bow across the string, by touching the string lightly with the finger or with a feather at one of the points where we wish it to divide. Even a varied air may be thus played by the harmonics only.

"The sounds belonging to a single cord or string, and produced by its spontaneous division into different numbers of equal parts, constitute, when heard together or in succession, what may be called a simple music of nature herself. It is produced pleasingly, as just described, by the single string of a violoncello, but also in a very interesting manner by the instrument called the Æolian harp.

"The *Æolian harp* is a long box or case of light wood, with harp or violin strings extended on its face. These are generally tuned in *unison* with each other, or to *the same pitch*, except one which is thicker than the others, and vibrates only half as fast, giving the lower octave to the others and serving as a bass. When the harp is suspended among trees, or is placed in any situation where the fluctuating breeze may reach it, near a window partially opened, for instance, each string, according to the manner in which it receives the blast, sounds either entire, or breaks into some of the simple divisions above described, the result of which is the production of a pleasing succession of musically-related sounds. After a pause this fairy harp may be heard beginning with a low and solemn note, like the bass of distant music in the sky: the sound then swells as if coming near, and other tones break forth, mingling with the first, and with each other. In the combined and varying strain, sometimes one clear note predominates and sometimes another, as if single musicians alternately led the band: and the concert often seems to approach and again to recede, until with the unequal breeze it dies away, and all is hushed again."

In all the above instances the vibrations of the strings would be inaudible, but for their connection with the box. Because of this, the sounds made by the disturbance of the strings by the wind is conducted to the extended surface of the box, and from this escapes rapidly enough into the air to make themselves thus audible. As the book expresses it: "In the piano, the harp, the violin, &c., everything depends on the perfect elasticity of the sounding board."

XXI.

MR. ARNOTT continues:

"The vibrations of strings fixed at their two ends may be experimentally studied by means of a long india-rubber tube, or a long spiral of fine brass wire, or even a long flexible rope.

"First on swinging the rope as in AA' (fig. 25), we find that it executes its vibrations in a definite period, depending merely on the length and weight and elasticity of the rope or tube, or wire helix.

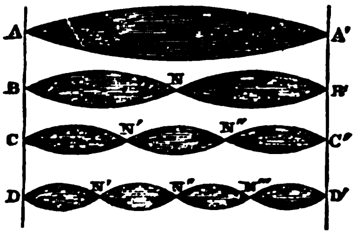

Fig 25.

"Next, on tilting up the end, A, sharply, we raise a hump which will pass on to the other end, A', in the same time as the whole string, AA', takes to make one vibration.

"As it cannot pass the end A', the wave is reflected there, and returns towards A with its former motion reversed, till on arriving at A it is once more reflected, and passes on towards A' as at first, these reflections continuing till at last all the motion is destroyed.

"If now we tilt up half the rope, BB', at one time, and keep tilting it at regular intervals, then, when the first wave is being reflected from B', a second is just starting from B; these will obviously meet at N in the middle of the rope, and as this point is solicited in two opposite directions at once [held], it will remain at rest, and the string will in consequence keep vibrating as if each half was independent of the other. The point, N is called a node; and the two bulging pieces of the string are termed *ventral segments.*

"In like manner the string may, with a little care, be divided into three ventral segments, with two nodes, as in CC′; or into four ventral segments, with three nodes, as in DD′, the divisions being distinctly visible.

"It is quite easy to throw a sounding string, such as a long string of catgut stretched over a sounding-box, into ventral segments, by lightly touching with the finger, or with a feather, at some exact division, such as a fourth or a fifth of the whole string, and then sounding this part in the ordinary way with a fiddle-bow.

"A simple method of showing these ventral segments is to fasten a white silk or light cotton string to one prong of a tuning-fork, the tension of the string being regulated by weights, W, in a scale-pan attached to the end of the string (fig. 26). On sounding the tuning-fork

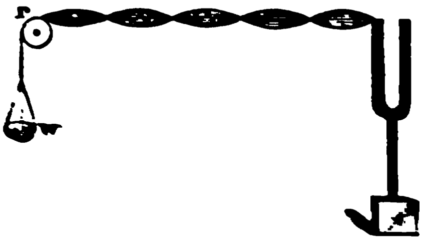

Fig. 26.

with a bow, the cord is thrown into one or more segments as the case may be; and by reducing the tension to a half or a third, we increase the number of segments two or three times. All the laws of vibrating strings may be thus experimentally established.

"The simple scale of sound which nature thus gives by the spontaneous dividing of a single string, corresponds with the series of *har-*

monics as explained above, and is called a *chord.* The vacancies in it, compared with the common musical scale, may be filled up by joining to it the notes of two additional strings, one a third shorter, and therefore giving sounds sharper or more acute than it, and the other a third longer, and therefore giving tones more grave. Of these additional notes, while part agree, or are in unison with certain notes of the principal chord, the remainder just serve to fill up its larger intervals, and to complete a scale of nearly uniform interval—as three ladders, having unequal intervals between their steps, might still, if placed together, complete a stair of easy ascent. The relation between these strings or chords is such, that the principal beats thrice for twice of the low chord, and the high chord beats thrice for twice of the principal; and in the usual scale of notes, the principal is the fifth note above the lower and fifth note below the higher.

"The numbers which express the relations of beats among the notes of an octave are easily found, from our knowing the relative number of beats in the notes of any one simple chord, and the relation as above described of the three chords forming the compound scale. The following table exhibits on the first line these relations, or the arithmetical expression for the beats of an octave; in the second line the corresponding lengths of a given string required to produce them; in the third line the English designation of the notes by letters, and in the fourth line the continental designation by names, these names being the first syllables of certain verses formerly sung by learners:—

Relations of vibrations .	1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
Length of string	1	$\frac{8}{9}$	$\frac{4}{5}$	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$	$\frac{8}{15}$	$\frac{1}{2}$
English characters .	C	D	E	F	G	A	B	C
Continental names . .	ut	re	mi	fa	sol	la	si	ut

"If the intervals in the musical scale were all equal, a performer might choose indifferently any note as a fundamental or *key* note, and would only have to attend to the number of intervals above and below it; but, in fact, the relation of the three constituent chords is such, that the third and seventh intervals in ascending from a key note are only about half as large as the others. It is owing to this circumstance that in *changing the key* on an instrument, certain notes belonging to other keys are about half a note too low or too high, that is too *flat* or too *sharp*, and must be changed accordingly. And hence, when an instrument is to be used to play in all keys, its larger intervals must be divided into two parts at least. The fact of these unequal intervals, ill understood, is what gives an appearance of great complexity and difficulty to musical science.

"*Melody*, in music, is when notes, having the simple numerical relations of beat which we have been describing, are played in succession: *harmony* is when two or more such notes are sounded together. The effect of both is delightfully increased by what is called *measure*, viz., making the duration of the notes or strain correspond with certain regular divisions of *time*. This gives to the listener an anticipation, to a certain degree, of what is coming, with the pleasure of having expectation realized, as happens similarly in regard to the metre and rhyme of poetry: it moreover enables the memory to retain musical combinations of sound. The airs of the Æolian harp, which observe no *time*, cannot be learned by note or repeated. The music of a single drum is chiefly that of *time*.

"The *accompaniment* of an air afforded to a singer by one or more instruments, and which is so pleasing, is chiefly the sounding simultaneously, in a subdued manner, some other notes of the chords to which the several vocal notes belong. *Duets* and more complicated *concert-pieces* have their origin from the same source: and highly cultivated musical sense can even follow and enjoy several melodies played together.

"Musical notes, by whatever instrument produced, have to each other the same numerical relations in the beats or vibrations which constitute them. The different qualities of tone, therefore, from different instruments, can depend only on peculiarities of the single beats, as to whether they are sharp or soft, strong or weak, and accompanied or not by their natural harmonics. Such is the extraordinary nicety of perception which the human ear possesses in this respect, that it can not only distinguish different kinds of instruments, as a flute and clarionet, playing the same note, but with respect to the human voice, goes to the extent of recognizing almost each one of many voices singing the same air. One of the greatest charms of concert-music is that a particular voice and the different instruments may take up, separately, parts of the strain suited to their individual expression: the flute and hautboy, for instance, breathe softness; the trumpet and drum arouse; the harp rolls forth its brilliant chords; the violin leads the clear sound through rapid and endless variety; and so of the rest.

"That there might be correspondence in instruments when played together, and a known pitch when played apart, it became necessary to fix on some tone or certain number of vibrations as a point of comparison. Hence tuning-forks are made of steel, with length of prongs calculated to produce a certain note. This note is usually the fourth A or *la*, from the bass of the pianoforte, and vibrates about 440 times in the second;—and when the note of the same name on any instrument is *tuned* in unison with this, the other notes can be easily adjusted according to the harmonic relations above explained.

"Almost every substance or contrivance that can produce a uniform continued sound may enter into the composition of a musical instrument: hence the almost endless variety which the world has seen. The chief classes of instruments are *stringed instruments*, *wind instruments*, and *bells* or *rods*.

"The *guitar*, as affording an accompaniment to vocal music, has many advantages. It is not too loud, yet the strains are very distinct: it admits of most touching expression; command of it is easily learned to the extent desirable as an accompaniment, by any one who should attempt to perform music at all; it is portable and cheap. The facility of accompaniment on it depends on this, that the player is able by one position of the hand so to touch the strings, that the sounds of all the six shall belong to the same chord—three positions of the hand, therefore, for one key, produces all the notes and chords which a simple accompaniment requires; and the hand soon falls into these so readily that the player is hardly sensible of exerting volition in regard to them.

Sounding Rods and Plates.

"Rods of wood, metal, glass, &c., *fixed at both ends*, will vibrate and divide into ventral segments after the same manner as the strings above described: but the same simple relations between the pitch of the note produced and the number of segments do not obtain. When a string of catgut tightly stretched divides into two segments, each half sounds the octave to the note produced by the whole vibrating string; but when a rod thus divides into two, each half vibrates more than twice as fast as the whole, and hence the note sounded by each half, is higher than the octave to the prime or fundamental note of the rod; the reason being that the force tending to restore the rod to its position of rest or equilibrium, is greater than that in the case of the string.

"If a steel or brass rod of two or three feet be fixed at one end only, and made to vibrate, either by striking or by means of a fiddle-bow, it will divide into wave-sections, like a sounding string. If the rod be three feet in length, it will vibrate about once in a second, and the motion will be plainly visible, but too slow to be audible. As we shorten the rod, the rapidity of quiver increases very fast; being *four*, *nine*, &c., times as fast when the length is reduced to a *half*, a *third*, &c. At about *four* inches, the vibrations begin to fuse together into a sound, and a steel rod one inch long will give nearly 1300 vibrations per second. An instrument to sound the notes of the gamut or scale might obviously be constructed out of eight rods whose lengths were connected by these relations. The metal tongues of the common musical-box belong to this class of sounding bodies.

"The motions of the free end of a vibrating rod fixed at the other end are much more complicated than might at first be supposed: they may be easily followed by fixing at the end of the rod a common glass bead, silvered inside, and watching the fiery path which the bead will trace out in presence of a candle-flame or strong sunlight. By striking the rod at different places or in different ways, the luminous track may be made almost infinitely various: sometimes curves of exceeding beauty are obtained. This method of studying the vibrations of a rod by the rapid motion of a luminous point is the invention of the late Sir Charles Wheatstone.

"The common *harmonica*, and the *claque-bois* of the French, consist of a series of glass, wood, or brass rods, graduated lengths so as to give a musical sequence of notes, and laid loosely on two strings or rods.

"The *tuning-fork* is simply a bent steel rod whose ends are free to vibrate, and whose constancy of vibration-period is insured by the stability of character which good-tempered steel possesses: so that it may at any moment be appealed to as a referee for the pitch of any required tone

"When a tuning-fork vibrates, each prong may divide into two or more ventral segments, just as a string or a straight rod may do. The deepest or fundamental tone is got when each prong sways to and fro as a whole: the first overtone or harmonic is got when each prong divides into two, the second when each divides into three, and so on. But, in accordance with the law already stated for vibrating rods, the first overtone is not the *octave* of the lowest or prime tone, but one which makes twenty-five vibrations while the first makes four. Thus the first overtone of a C fork, which makes 256 vibrations per second, will be a note making 1600 per second: and the others rise in the following proportions:—While the *first* overtone makes 9 vibrations, the second, third, fourth, &c., will make 25, 49, 81, &c. That is, the vibration rates of the whole series of overtones are as the squares of the successive odd numbers 3, 5, 7, 9, etc. The vibration of a tuning-fork may be readily shown by bringing it near to a light ball or a small bead suspended by a thread; the bead will be projected to a considerable distance."

XXII.

THE history of Sound extends back thousands of years. For many centuries it was not known that it could be conveyed by any medium but air. Because of this ignorance, the air wave theory became popular, although there were some, and perhaps many, of the Greeks who accepted Plato's idea, that it consisted of infinitesimal particles of matter that found their way through the air to the ear, and thence to the soul.

A material disturbance happens in the outside world. Very quickly, as a result of it, the soul experiences the sensation of hearing, a sensation which we find by experience varies with the disturbance, and practically is always similar for the same or a similar disturbance. The disturbance does not come to us; nor is it necessary that we see or touch it, in order to experience the phenomenon of Sound. Then must it have produced something that in some way delivers to us a picture, or copy, or at least gives us accurate information in regard to it.

To correlate it, a certain amount of education is necessary. That is, the soul, every soul, must learn the significance of sounds, in order to benefit by them. But this is readily done, and thus arises the use and benefit of language, one of the principal means for the education and happiness of mankind.

But first let us be specific as to what Sound is. For, as we have seen, in the confused or ignorant ideas in regard to it, even the definition of what it is has been badly mixed, the absurd claim being made that it could only exist as there were beings to hear it. That is, the definition of Sound and the sense of hearing, in the want of knowledge which connected with the whole matter, have been confounded.

Sound, as we have suggested, is the copy of disturbances in the material world, mostly happening in air, which, carried to the ear, produces the sensation of hearing. Its existence depends upon that of disturbance, or shock. So long as storms exist, or the note of a bird, Sound will exist, although it is not the storm or the bird, but a report of the disturbances made by them, sent off as an epistle to notify intelligent beings what is going on in the natural world.

Like as a letter conveys information to the person addressed, so does Sound carry information of disturbances more or less distant to sentient beings. It is a communication of nature with spirit.

And as letters must have a regular and consistent form according to certain mutually understood conditions, so sounds must have. Letters or words mean certain things, because an artificial arrangement has been made between individuals that they should; and sound equally means certain things, or a certain thing, what particular thing each means having been learned by experience or education.

Some sounds are very beautiful, like the notes of birds, and, at times, of the human voice.

Light and Sound are to man among the most important of the phenomena of nature. Light is unquestionably the most remarkable, but both are causes of sensation, and there are other strong resemblances between them. Light produces vision and colors, and with it are closely connected heat and electricity. It, too, is infinitesimal particles of matter created in infinite quantities for use in the vast spaces of the heavens, and also artificially upon the earth. Its speed is equal to that of any material thing known to us, and it excels all in beauty.

> "God said, let there be Light, and there was Light."

The functions of Sound are confined more closely to the earth. It, too, carries its own speed, a very respectable amount for the distance it travels.

In a moment, in the twinkling of an eye, it is created, and generally is as quickly dissipated, the machinery that makes it being of the simplest kind. Only when it becomes music, that is, when held in metals or resounding bodies, does it perform its more remarkable phenomena, here illustrating that universal principle in nature, that "in union there is strength." On a smaller scale, it accomplishes here, what water does by gathering in rivers, ponds, oceans. It is in these conditions that there is opportunity to study it, and hence that most discoveries in regard to its action may be made.

When a tuning-fork is struck by something, or something is struck by it,—it seems to make but little difference which,—it immediately vibrates, and also emits Sound. And these two phenomena are of such spontaneity that by the eye or ear it would be impossible to tell which is first. The bookmen have advanced several hypotheses in regard to them, all of which, so far as we can see, are based upon nothing.

First, they have the theory, before referred to, that they are the result of vibrations of hypothetical corpuscles that are supposed to make up the material of a part of the fork, and at the same time it is stated that the fork is composed of two other sorts of particles. The last apparently are thrown in as ballast. But the first are evidently introduced because, in experiments, several scientists have found that there were infinitesimal particles of matter connected with the vibrations which connect with Sound.

These hypotheses were apparently accepted without much, if any, discussion; by whom introduced does not appear.

Unfortunately, the old theory of Sound helped prevent right perceptions. All of this had to be got rid of before any advance could be made. And thus this platitude of hypotheses, utterly worthless, has been accepted with the long time vulgar theory of air waves, and in spite of many advances in different parts of the theory of Sound, has prevented a full exposure of its errors to the present time.

XXIII.

WE will here call attention to the fact that every proposition in regard to the essential nature of Sound, which appears in the undulatory theories, is an unproven hypothesis, although stated in text-books and elsewhere as a fact.

This is true of all that is said about sound waves, and it is also true of all that is said about particles or corpuscles of which bodies are composed moving in them, to make them vibrate. There is no truth in any of this. In all such cases vibration is caused by an electric force made for the purpose by shock or friction, apparently operating through the interstices of the body; and, so far as we now remember, always connected with the phenomena of Sound.

The conditions are plain enough. We have different kinds of metal, as iron, copper, steel, that being struck are thrown vigorously into motion, with which is connected Sound. There are two things which we have that we did not have before, Motion and Sound; both evidently the product of the blow. There is no reason to suppose that the metal, either kind, has changed any, excepting that it moves, but man changes not because he moves, neither does a wagon, or a railroad car, or necessarily anything. The motion is something distinct from them all; it makes them move, it makes anything move from a ball to a sphere, so long as it remains in the thing. That is what it is for.

But what is it? It is unquestionably a principle in itself, and may fairly be classed as one of the conditions of matter, that part of it which moves, and makes other things move if in sufficient quantity.

When we say motion is a part of matter, that part which moves, we make a very broad definition of matter, including everything which cannot think. That is, it is a division of creation into two substances, that which thinks and that which does not. Motion has sometimes been called the mind of matter, but it certainly does not have intelligence. Nor is it possible to conceive of anything moving unless it has substance; but all things which have substance, and do not have intelligence, may be fairly classed in the great division of matter. And matter itself is divided into classes or principles, each having its own function. And certainly the function of motion—to move things—is one of the most important that there is.

Further, in regard to motion, we know that it must be composed of infinitesimal particles of a moving substance. These to us are invisible, but we know they pervade the pores of things, possibly the whole substance as water does a sponge, and, as they do it, cause these things to move, slowly or swiftly, evidently in accordance with the amount and quality of motion which enters into them.

And this motion, too, thus entering, will pass under certain rules or conditions from one body into another. And always when it does the first body stops, whilst the second, or body hit, starts at the same pace, and will proceed so long as the motion continues in it, though gradually this motion is lost by friction or impediment.

We know, too, that motion may always be aroused, is always aroused, by pressure or shock. But shock it is that always produces Sound. And thus it is that we may see how intimately connected are shock, motion, and Sound.

What, then, is the function of the fork, wire, or other metal? Evidently from our knowledge of the effect of vibration, this part of the machinery is to make that particular kind of sounds, which we call musical sounds. That is, musical instruments are in this way made, which, whether of metal or of vocal organs, fill the world, and perhaps the universe, with music not only intrinsically useful but some of it most delightful—sweeter than honey and the honey comb.

Motion, then, like sweetness, or beauty, or indeed everything else, is one of the principles of which all matter is composed, each one performing the special function for which it is made. It exists in vast quantities, and can be manufactured with great facility, but like all other things can never be obtained where it is not, and can only operate where it is.

In the Phædo of Plato, Socrates says:

> "I cannot help thinking that if there be anything beautiful other than absolute beauty, that can only be beautiful in as far as it partakes of absolute beauty—and this I should say of everything. And if a person says to me that the bloom of color, or form, or anything else of that sort is a source of beauty, I leave all that which is only confusing to me, and simply and singly, and perhaps foolishly, hold and am assured in my own mind that nothing makes a thing beautiful but the presence and participation of beauty in whatever way or manner ob-

tained; for as to the manner I am uncertain, but I stoutly contend that by beauty all beautiful things become beautiful. That appears to me to be the only safe answer that I can give, either to myself or to any other, and to that I cling, in the persuasion that I shall never be overthrown, and that I may safely answer to myself or any other, that by beauty beautiful things become beautiful."

This is a splendid perception by the "Master Mind of the Ages" of the principles upon which the universe is constructed, of which there are millions and every one the best possible for its purpose. Nor is there anything superfluous, but in each case the particular principle wanted is used to furnish its part of the material necessary for the production of any or all the different things which constitute the universe.

Plato says: "By beauty all beautiful things become beautiful." And adds: "And this I should say of everything."

But among these principles, and one of the most important of all, is that of Motion.

Unquestionably it is responsible for the movement of matter throughout the universe. It is the principle in creation made to do this part. No other connected with matter can be its equal. No other can exist in such quantities, or be so often used.

Constantly it is drawn upon in the billions of existing things; in many comparatively little, but in all some, if only enough to provide for change and decay.

And so, too, we think that this, as all other principles of which the universe is composed, exists in its purity.

Thus may we account for the, to us, marvelous speed of light and electricity, or the beautiful display of the aurora in the star-lit heavens.

But it is no more true that these different principles exist in the universe, than that, when wanted, they must be sought where they may be found, and obtained through the processes appointed for such purpose.

It is well known that pressure and also shock produces motion, under some circumstances any amount of it, and under all circumstances some. Shock or friction, and pressure, are among the most common means of obtaining motion. Strike a ball, and, if the blow is good, see how quickly it will soar into the air.

It becomes, then, evident that the shock which produces Sound must produce motion. It does produce motion in Sound, a splendid quality of it, that will carry it in all directions, and through different mediums. This comes from the blow. And being moving matter, Sound makes different bodies vibrate in which it is confined, as the prongs of a tuning-fork or wires of a piano, and thus, too, directly or indirectly, makes the graphophone record.

Ignoring these facts and burdened with undulatory theories, the hypothesis, before mentioned, has been advanced, by whom we do not know, nor why, but it has been generally accepted in text-books, that solid bodies are composed of different kinds of particles of matter, the smallest of which are termed corpuscles; that these last are incited by a blow to make metals and the prongs of a tuning-fork vibrate, how, is not told, though it is admitted that belonging to solids they cannot themselves separate from each other, as particles of fluids can. There is nothing whatever to warrant such an hypothesis, and on the other hand positive testimony that it is not true. It is going to a rock for water, instead of a spring.

All motion comes from supplies of motion wherever they flow, infinitesimal and unseen, but always at command. And it follows that the motion which takes place in Sound belongs to that part of matter which circulates through bodies, and not to that part which makes them. That is, to fluids and not to solids.

Changing the words beauty and beautiful to motion and movable, for the principles operating are precisely the same, we can suppose Plato to say, "I can not help thinking that if there be anything movable other than absolute motion, that can only be movable in as far as it partakes of absolute motion —and this I should say of everything. And if a person says to me that the form, conditions, or anything else of that sort is a source of motion, I leave all that which is only confusing to me, and simply and singly, and perhaps foolishly, hold and am assured in my own mind that nothing makes a thing movable but the presence and participation of motion in whatever way or manner obtained; for as to manner I am uncertain, but I stoutly contend that by motion all movable things become movable. That appears to me to be the only safe answer that I can give, either to myself or to any other, and to that I cling, in the persuasion that I shall never be overthrown, and that I may safely answer to myself or any other, that by motion movable things become movable."

XXIV.

THAT Sound makes vibration is again demonstrated from the fact that the vibration in any instrument always begins with the sound, and ceases when the sound stops.

Take a tuning-fork; the prongs of the fork begin their vibration with the advent of the sound, vary it precisely as the sound may be varied by being drawn off from the fork, and stop when the last bit of sound leaves the fork, nor do they stop before.

If the sound did not make the vibration, why should this vibration begin, stop, or vary, as the sound begins, stops, or varies?

If we saw that a weathercock always turned with the wind, and never turned unless the wind did; and that if the wind was light it turned slowly, but if strong quickly, we should be justified in saying that the wind turned the weathercock, and should not be justified in saying that the weather-cock turned the wind.

After the shock made by striking the tuning-fork, we know that Sound is in the tuning-fork, for we can hear it. We can also draw the sound from the fork, and conduct it to our brain or elsewhere.

Shock, then, makes Sound. Sound is motion, and this of necessity means some substance in motion, that is, matter in motion, unable to get out of the fork except slowly and making the prongs of the fork vibrate, when they constantly throw off more or less of the sound, probably always, other things being equal, enough to supply the ears effectively when the fork is quite near them, especially if the flat sides of the fork are parallel with the ear.

Sounds thus confined are audible for only a short distance, but if conducted, as they can readily be, to sounding-boards, as of a piano or violin, or reinforced by the unison vibration of air or other bodies, they will be heard far more clearly, and for much longer distances. The universal principle, again, in nature that effects are proportionate to amounts.

For because of the extended surfaces of the sounding-boards, and perhaps for other reasons, Sound is thrown off far more rapidly from them than from wires or strings. And, as we have seen, it can be conducted far more quickly from the tuning-fork or other such musical instrument, than it can be thrown off. A tuning-fork which, suspended by a fine cambric thread, would vibrate 252 seconds, if its stem is placed upon a thin pine board of good size will be emptied of Sound in 10 seconds.

Perhaps nothing starts off in life with more activity and independence than Sound, but its life lasts only a few moments, when the motion returneth to the source from whence it came; and the sounds, though they be exquisitely beautiful, and float as gaily as a banner in the air, in another moment fade and die like an exhalation of the evening.

The ability of sounds to impress themselves upon the mind, or, perhaps, rather to arrange themselves in the brain, is accomplished, we think, in a similar way as the graphophone or telegraphone record is made. And thus we have the memory of sounds arranged for in the brain as those of vision are, that is by records.

And this again illustrates how Light and Sound have so many characteristics in common. In the great schools of creation they are equally engaged in educational purposes, one operating by vision, the other by the sense of hearing.

And these schools belong to our present existence. Doubtless they are duplicated in the different spheres, only adapted to the different conditions of learning which may exist in these. Doubtless, too, there are other and greatly advanced systems of learning in which the studies are taught that connect with a higher existence, which the Bible speaks of as Spiritual. But all this lies beyond, and will be unfolded as we enter it, or as we are fitted for it. Our duties now are here, where, whether we realize it or not, we are being taught in nature's system of schools, without money and without price.

And thus silently the arrangements are made so that Sound finds its way to the brain, assisted by the auditory nerve and much other remarkable machinery, where it is retained at the command and for the use of the individual. By accident man has been able to use it in making the graphophone and telegraphone records.

We have seen, that by sweetness things become sweet; by odor, of which there are many kinds, they become fragrant,—and with the particular odor that enters into them; by flavor, the particular flavor which belongs to them, they may be tasted; it is equally true,—for this is a fundamental principle in the construction of the universe to which there are no exceptions,—that by motion, the principle of motion, things are moved. By motion also Sound is created.

Why, then, are hypotheses introduced, that motion originates where it does not exist.

The fork lies motionless wherever it may be, and would so lie until rust by a very slow process destroyed it.

So far as we can see, all of these hypotheses connected with the formation and character of Sound are based upon nothing. On the other hand, that Sound is created by shock or friction is of itself reasonably certain, as Sound is known to be electrical, and electricity is made by friction, which is a succession of diminutive shocks.

Let us now analyze the character and actions of Sound, to do which there is such remarkable opportunity that it wouldn't seem possible that any mistake could be made as to its essential nature.

First, directly after the blow, but never before, it appears in the fork, or other musical instrument, which it makes vibrate rapidly, and from which it is thrown off slowly into the air. But plenty of Sound remains in the fork for us to experiment with, and we find that it can be conducted from the fork rapidly by placing the stem upon a thin pine board or ordinary deal stick.

In this experiment, we would call attention again to the fact, that the vibration of the fork lessens in exact proportion as the sound flows from it, which we consider as absolute proof that the sound makes it. For if the vibration made the sound, there couldn't be any reason why it should stop when the sound flowed away; but if the sound made it, it must stop instantly. It also decreases proportionally with the sound; that is, if the sound runs out faster it decreases faster, varying exactly and at all times with the sound, showing conclusively that it is caused by the sound.

By placing the other end of a deal stick in the mouth, the sound will be carried rapidly from the fork to the head, where you can recognize it to be a precisely similar sound as escaped from the fork through the air to your ear.

The principle of unison vibration furnishes another complete proof, as we have before shown, that Sound makes vibration in musical instruments.

XXV.

THE sounding body is the source of Sound, although, as in every occurrence of nature, there are antecedent causes, any number of them, essential to the operation of this immediate cause. These antecedent causes are first the shock or disturbance, and back of the shock electricity and undoubtedly other matter, to furnish the material from which Sound is made.

That the sounding body determines the character of Sound, as we have seen, can be demonstrated by the graphophone record. We know each sound will always reproduce itself, either in the mind or graphophone record. For the sound of a robin we look to the robin, for that of a bell to a bell. And so each sound is made by a particular instrument, and always a similar sound by the same instrument, as each shingle or clapboard or board or plank is, in a saw-mill.

Shock submits certain electrical matter to the action of different bodies. Evidently each body is constructed, or at least most bodies are constructed, upon a different plan in the character, form, and arrangement of the particles composing them. And therefore when the material made by shock, and which consists of moving matter, circulates through these bodies, it causes them to vibrate differently, by which vibration the sounds are undoubtedly in part manufactured. It would appear, too, that the moving material, enters into the composition of these sounds.

These vibrating bodies are mills for the manufacturing of Sound, as much so as the different mills made by man are for the manufacturing of the things which they produce. And thus machinery is just as essential in determining the character of Sound, as in the case of anything made by man; these are fundamental laws of creation, prevailing everywhere in connection with material things.

And this Sound is one of the great gifts provided by nature for the use of intelligent beings, free to all. And there are infinite varieties of it, but the market it supplies is also infinite.

It follows that the following things are demonstrated with absolute certainty in regard to Sound:

It is caused by disturbance or shock, which of necessity is motion or a result of motion; it represents an exact picture or copy of the disturbance, as we have before said, as much so as the picture made by vision of a tree is an exact copy of the tree.

The substance, of which Sound is made, moves similarly to a shooting star, or the aurora borealis, or electricity, or anything else that moves, and evidently by the same or a similar force. That is, Sound moves, like everything else that moves, because of the principle of motion, and in accordance with the amount of motion connected with it. And so a wagon moves, the honest horse manufacturing motion by a pull. And thus, too, man manufactures motion when he strikes a ball or throws a stone. And this is that principle which constitutes the life of the universe, and thus is sometimes called the mind of matter. Certainly it keeps everything from stagnation, and makes of the universe a palace to live in, which the poor, as well as the rich, have an equal chance to occupy. There is room enough for all, and everyone may improve his chances by honest labor. The air, the water, the light, and the scenery are furnished free.

And unquestionably Sound can represent the most delicate possible distinction in motion, and hence comes the most delicate possible distinctions in Sound. The mind is perfectly capable of understanding all this, and does understand it, as it does many other of the wonderful works of nature, with veneration and awe.

As we have seen, too, the sound, manufactured through the operation of this machinery, may produce an instrument, which, if disturbed as the original body was, will reproduce the sound; that is, make another body, perhaps a very different body, but able when disturbed by shock to recreate the sound which made it.

And apparently this might be continued indefinitely, the same as, by light, pictures may be indefinitely reflected in mirrors.

There is, however, this difference, that in one case there is the copy of a substance at rest, and in the other of one in motion. We would suppose the last to be the most difficult to make, but cannot with certainty see that in any other respect they differ very much, and not at all so far as each is an exact copy of what it represents.

And in every case results obtained may vary in size, or intensity, and therefore be fitted for the scale of size in which they occur. We are assuming that in some way this scale is of infinite extension, which seems necessary to sustain the fact that in the retina of the smallest eye the whole heavens with all the spheres which they contain are perfectly reflected.

The intensity of Sound, which depends upon, and indeed means, its amount, is proportionate to the strength of the disturbance.

And equally according to the amounts will be the distance which the sounds will flow. This, too, other things being equal, is a universal law.

XXVI.

PROFESSOR TYNDALL in his book "On Sound," says:

"From a boat in Cowes Harbor, in moderate weather, I have often watched the masts and ropes of the ships, as mirrored in the water. The images of the ropes revealed the condition of the surface, indicating by long and wide protuberances the passage of the larger rollers, and, by smaller indentations, the ripples which crept like parasites over the sides of the larger waves. The sea was able to accommodate itself to the requirements of all undulations, great and small. When the surface was touched with an oar, or when drops were permitted to fall from the oar, into the water, there was also room for the tiny wavelets thus generated. This carving of the surface by waves and ripples had its limit only in my powers of observation; every wave and every ripple asserted its right of place, and retained its individual existence, amid the crowd of other motions which agitated the water.

"The law that rules this chasing of the sea, this crossing and intermingling of innumerable small waves, is *that the resultant motion of every particle of water is the sum of the individual motions imparted to it.* If a particle be acted on at the same moment by two impulses, both of which tend to raise it, it will be lifted by a force equal to the sum of both. If acted upon by two impulses, one of which tends to raise it, and the other to depress it, it will be acted upon by a force equal to the difference of both. When, therefore, the sum of the motions is spoken of, the *algebraic sum* is meant—the motions which tend to raise the particle being regarded as positive, and those which tend to depress it as negative.

"When two stones are cast into smooth water 20 or 30 feet apart, round each stone is formed a series of expanding circular waves, every one of which consists of a ridge and a furrow. The waves touch, cross each other, and carve the surface into little eminences and depressions. Where ridge coincides with ridge, we have the water raised to a double height; where furrow coincides with furrow, we have it depressed to a double depth; where ridge coincides with furrow, we have the water reduced to its average level. The resultant motion of the water at every point is, as above stated, the algebraic sum of the motions impressed upon that point. And if, instead of two scources of disturbance, we had ten, or a hundred, or a thousand, the consequence would be the same; the actual result might transcend our powers of observation, but the law above enunciated would still hold good.

"Instead of the intersection of waves from two distinct centres of disturbance, we may cause direct and reflected waves, from the same centre, to cross each other. Many of you know the beauty of the effects produced when light is reflected from ripples of water. When mercury is employed the effect is more brilliant still. Here, by a proper mode of agitation, direct and reflected waves may be caused to cross and interlace, and by the most wonderful self-analysis to untie their knotted scrolls.

"This power of water to accept and transmit multitudinous impulses is shared by air, which concedes the right of space and motion to any number of sonorous waves. The same air is competent to accept and transmit the vibrations of a thousand instruments at the same time. When we try to visualize the motion of the air—to present to the eye of the mind the battling of the pulses direct and reverberated—the imagination retires baffled from the attempt. Still, amid all the complexity, the law above enunciated holds good, every particle of air being animated by a resultant motion, which is the algebraic sum of all the individual motions imparted to it. And the most wonderful thing of all is, that the human ear, though acted on only by a cylinder of that air, which does not exceed the thickness of a quill, can detect the components of the motion, and, by an act of attention, can even isolate from the aërial entanglement any particular sound."

The above is a very handsome literary passage but not a single phrase in it has the remotest connection with Sound. That "the sea is able to accommodate itself to the requirements of all its undulations, great and small," or, indeed, to any and all things which take place upon its surface, or in it, is without question correct; and so, too, is the whole world. For everywhere on land or sea a wonderful variety of things is always taking place, and there is room for the whole.

The law of resultants is perfectly sure to hold good anywhere, and under any circumstances. Doubtless, too, in air, though we cannot always see it, many and some quite remarkable occurrences are constantly taking place, with abundance of both room and opportunity.

A snowstorm is now going on outside as I write, and a hundred thousand millions of very fine and rapidly moving snowflakes find abundance of room to make their way from the overhanging clouds to the whitened earth, where, too, there will be plenty of room for them, perhaps the remainder of the winter. But all this has nothing, or very little, to do with Sound.

The waves which Mr. Tyndall refers to, when a stone or stones are cast into still water, have nothing to do, directly or indirectly, with the method by which Sound is transferred.

The myriads of snowflakes driven before the storm are far more representative of Sound and its manner of journeying, although at their swiftest pace neither in size or speed do they compare with it.

We have met with a great deal of flattering mention of these water waves in different books on Physics, but never any complete, and seldom any partial, description of the forces by which they are made.

All water waves have a depth, which is called their amplitude, from crest to sinus (hollow), or sinus to crest, of about one to ten as compared with their length. This is an indispensable characteristic of water waves, as much as sphericity is of a sphere, or roundness of a circle.

Disturbances made in the water below the surface spread but a little way toward the top. The disturbance made by a fish is seen only when the fish is near the surface, and good-sized stones or other bodies which, thrown into a pond, would cause a system of waves that would extend many rods, will, when dragged upon the bottom at four to six feet of depth, cause no waves upon its surface.

The water waves which form so magically and spread so beautifully are produced by the different principles of motion, especially gravity and momentum.

A force or motion is imparted to the stone by the one who throws it, which is increased by gravity, when a resultant motion takes place and the stone enters the water, pressing it downwards and laterally, which thus starts the first ring of waves. In this ring there is quite a movement of the water thrown up by the stone. This is illustrated in throwing a stone beyond a chip or article floating on the water, to bring it shoreward. Immediately, because of gravity, the water rushes in to fill the space through which the stone passed. In doing this it rises above the normal level, thus starting the second ring of waves.

The water is again drawn down by gravity and between the two forces (the motion first caused by the pushing of the stone, and gravity) oscillates a number of times, forming each time a ring of waves, whose height decreases as the rings enlarge.

Thus far we have but one system of waves. But if other stones are cast into the water, other precisely similar systems will be formed, which, unless too numerous, will, by the principle of resultants, pass through each other. And this because of the mobility of water, which will permit each different particle to separate or not from its comrades, and thus conform to the numerous forces, individual or resultant, influencing it.

There will, however, be a certain amount of visible disarrangement where the different systems meet.

All of this readily takes place, and can be perfectly understood. The water adapts itself to the different conditions because of its mobility; and thus the disturbances can be carried for considerable distances without any particular body of water moving far horizontally, though over a large surface, as influenced by momentum and gravity, it may rise and fall for a short time. But this is all that could happen, for the particles are small and the forces that impel them limited by the conditions.

And so a body of soldiers might keep time in lifting up and replacing their feet constantly in the same tracks, and if there were large numbers of them, such movement might exist over a large surface of ground. But it would result in little, for the movement is too contracted. To accomplish what they are intended for, the soldiers must march.

The birds make long distances, from the equator to the Arctic circle; provisions and products of all kinds are transported from where they grow, or are manufactured, to where they are used; light flies from the illuminating body to the locations which it illuminates, and Sound from the place of disturbance to the ear where it makes known its messages.

That Sound in its essential nature is different from other substances is not true, or indeed that there are any substances or any effects by any different methods than the usual one of existence and contact.

The last paragraph quoted from Mr. Tyndall is without any warrant whatever, and in the way that it is intended absolutely devoid of truth.

Sound as we all know uses air as a medium, and a very important one, to pass through, the same as vessels use the ocean, or railroad trains the earth, and quite probably draws from it, in part or in whole, the material for its own manufacture. All suggested beyond this by Mr. Tyndall is purely imaginative, and utterly worthless.

By a law of differences wide extended as the universe, things are created differently. In every case a thing is different to a certain extent from every other thing. This difference may be very slight or it may be very large, but it always exists. And, as in Sound, every body has its normal vibration, so everything has its normal use. It is made for a purpose. And thus, throughout the universe, there are innumerable different things to be accomplished; and so far as these are different, there will be corresponding differences in the things made to perform them. Order is nature's first law. That different things have different functions, and that every particular function is accomplished by some particular or appropriate design, is always true. And this is equally true of animate or inanimate things; and therefore is it true, that you cannot gather grapes from thorns or figs from thistles.

It follows that there are principles to perform every purpose in this infinite universe, as many and as various as the things to be performed. And this, as we have already said, is equally true of motion as of any other principle. And therefore all movement comes from a single principle, that of motion made to create it.

Any thing that moves is governed by the amount of motion that moves it, and amount of resistance, from whatever cause, to the movement. In accordance with these principles, particles of water, in the system of waves referred to, do not move very far, alternating constantly in short distances. And as there are no new principles involved, there are none to be drawn from; nor any suggestion that under any circumstances there are any other principles of movement excepting, that anything, when moved, passes from one place to another, the distance depending upon the amount of moving power, and resistance.

The movement of grain or cornstalks in a field has been mentioned as similar to wave motion, which is not at all true. In water every particle moves as a whole. The grain stalks do not, each one being fastened in its place. They bend but do not make a complete movement, acting in this respect similarly to a tree. The movement of either would be impossible with sounds, or any movement that did not carry the photograph or copy of the disturbance from the sounding body to the ear, for that is what it is made for. Gravitation the principal force acting in water waves, cannot affect Sound.

Sound is a system of signals for the purpose of conveying information, and imparting pleasure, to sentient beings dwelling in material conditions. And nature accomplishes this in her usual and only method of operation, at least in material conditions, by conveying combinations of matter sufficient in number to represent all possible sounds, and this means practically a possible sound for every material body; and things are arranged so that this can be done. That is, material bodies are made capable of doing this. And these,—as we have said, for it is important in such discussions that fundamental principles should be constantly borne in mind, and therefore a certain amount of reduplication is not only excusable but necessary, —are accomplished by the one method that nature has adopted for interaction between mind and matter, the introduction of combinations of matter to the soul.

Nor is it possible for the human mind to conceive of any better method for all the purposes of creation than this; a law absolutely without limit in the possibilities of results in any direction in which it may be used.

Included in it are time and space, as well as action, so that things can pass each other—all things, any number of things. And this is the universe in which we live, where apparently the infinitely small may be just as assertive and useful as the infinitely large. And therefore the smallest mixtures of matter, which can fill the air as full of particles as a snow storm, will perform their functions as certainly and accurately as the largest.

In all such cases the thing itself must go; rivers by their courses through large tracts of country from the mountains to the sea; people and animals constantly in motion, by which intercourse takes place; movement everywhere, a veritable movement of bodies, and nowhere greater than in the vast spaces which distinguish the heavens. Here every particle of air moves in freedom; and here it is that light passes from sphere to sphere. The trees are fastened in their places, but the leaves are as free to move as the dust, or the birds, except that they depend upon outside forces for their motion. The universal principle of action is movement, naturally free to intelligence, more or less restricted with inanimate things. The spheres are held to their courses, and ordinary matter is quiescent unless the principle of motion is introduced to move it. Life in its full sense means motion constant and free. Liberty is freedom to go where we please, and to do what we please, but restriction may be desirable or even necessary.

Two friends meet, or have correspondence pass between them; but no communication passes unless some substance passes. This is the one and the only law by which intercourse takes place, or one substance affects another, to which Sound is no exception, but is composed of matter—unquestionably very diminutive in size, according to our idea of size—which makes the journey from the cause of disturbance to the listening ear, and there affects the mind by this only method known in nature, contact of matter,—designed for this especial purpose,—with spirit.

XXVII.

CERTAIN general facts have become conspicuous in this discussion and may be made so to all. First, that Sound has nothing whatever to do with air pulses, or with air, excepting as a medium to pass through, or, if the statements of all text-books and encyclopædic articles on Sound are true, that its intensity depends upon the density of the air in which it is made, a source of material for its manufacture.

If the statements thus made are true, and we know of no reason to doubt them, Sound is certainly composed in part of material drawn from air.

The experiments of Hauksbee and Priestley, tried repeatedly, showed that Sound made in air of double density could be heard twice as far, and if made in air of triple density, three times as far, although in each of these cases, the sound, after leaving the glass jar where it was made, was carried by air of single density.

We know of no possible explanation of this except that Sound depends upon the density of the air in which it is made, ,because the material or a part of it from which it is made comes from air.

The great electrician Oersted demonstrated that Sound is composed in part of electricity, and this, we think, is one substance drawn on in air for the manufacture of Sound. Electricity is known to exist in air, at least to a considerable extent, and there would appear to be no other source for it when sounds are made in a glass jar, and, generally, no more natural source than this.

Trying to conform to a bogus theory of Sound, those who discovered that the intensity of Sound depends upon the density of air where the sound is made, tried to explain it,—and so scientists of the present day do,—by asserting that it showed that air of a double density was necessary to carry Sound of a double intensity. It showed nothing of the kind It simply showed that there was sound of this quality to be carried, and such sound could only be got where there was air of double density. Certainly no air of any density could carry any Sound unless there was Sound to carry; you must catch your hare before you cook him. The fact that this sound of double intensity was perfectly carried by air of single density, when outside of the jar in which it was made, is additional and positive proof that the carrying power of air alone does not explain the problem. That it was thought to, only shows how difficult it is to get out of a rut. It did not and could not show this. It did show that in air of double density there was material to make such sound, and that it made it; and that air of a triple density made sound of a triple intensity; and that either of these qualities of sound, as well as sound of single intensity, could all be carried by air of single density. And if experiments reported of hearing sounds made on the earth in balloons at a great height are correct, air of far less than single density will carry sounds of full intensity, as well and as far as they would be carried upon the earth by air of full density.

These facts alone demonstrate Sound to be corpuscular,—

largely made from material gathered in air, of which electricity would appear to be a most important factor.

That Sound is not air pulses is proven repeatedly both positively and negatively. For we know it is something else. We know it is made out of air in whole or in part, as has just been proven. We know that it is made in a body, as a tuning fork, and with difficulty gets into the air, whilst it may be easily conducted through other bodies at long distances and great speed, many times faster than in air, and thus can be conducted into the head without ever entering the air. All statements that it is conducted in air or anywhere else by condensations and rarefactions, or any so-called wave system, are absolutely false; and therefore is it that when we have repeatedly offered $1000 and $2000 in the leading scientific and other Journals of America and Europe for proof of this, there has never been one word of response.

Again, Sound has no effect upon flames, except in rare instances where a flame and the sound have the same normal vibration. Otherwise make any amount of Sound near a flame, any flame, as a lamp or candle, being careful not to start pulses of air, and it will not affect the flame a particle. Any one can try this experiment very easily. On the other hand, a very little disturbance of the air will extinguish them. And if Sound was air pulses, it would extinguish them.

And yet again, the statement that the destruction caused by explosions has anything to do with Sound, is entirely erroneous; all such destruction comes from pulses of air, or gases. Sound in all cases and everywhere is harmless; it wouldn't hurt a fly. The lightning will kill, but the thunder never injures. As we have mentioned, the speed of Sound is always some six times greater than the fastest hurricane or tornado, which are composed of pulses of air, and therefore the sound of a storm always precedes the storm, and the sound of a severe storm at one side of you, may be heard long distances where the storm does not come at all.

All of this shows that so-called sonorous waves are entirely mythical. On the other hand air is exceedingly useful, as we have repeatedly mentioned, as a medium for Sound to pass through, or at times to vibrate in.

Sound in all cases is corpuscular, composed of infinitesimal particles of electrical matter, so small that they can pass each other in infinite numbers, like particles of dust, and so small that, like far the greatest number of things, they are invisible to us.

XXVIII.

THE following, which gives further light upon the hitherto unexplained part of this subject, we quote from "Ellen," Vol. III., because of the great convenience and assistance of the dialogue in such researches:

"Because of this principle of motion is it, as Ellen has suggested, that Sound can make a graphophone record or telegraphone record. If it was not itself in motion, it would not do this at all; and if its motion was not an exact copy of the disturbance it represents, it could not do it at all; as it is, under certain circumstances, it cannot help doing it, any more than any machinery properly placed can help doing what it is made to do. But it would not be possible for Sound to make the indenture, or the plow to do the ploughing, or any instrument, or machinery to do the work it does, if it was not designed to do it. And this is true of every material thing.

"With careful study, the whole process of this remarkable thing Sound becomes plain. In the first place this principle was evidently arranged for in the creation, from the fact that every body, or practically that, has its normal vibration. Then comes shock, the great precursor of motion; and this motion is produced in the body struck. There can be no possible question that the shock arouses motion, for it always does it. But in this case, and in all cases if the body be hard, Sound is also produced by the blow. And Sound is motion, that is matter in motion, and therefore makes bodies vibrate in which it is made, or through which it passes. And the same body always makes a similar sound, and, if a material body, can make no other. These different brands of sound vary in the same manner, as the different kinds of apples, or pears, or plums, or any fruit or grain or vegetable; and are made in a similar way, as the different trees, or vines, or roots, make the different kinds of apples, if all the trees are apple trees; or of fruits, if representing different kinds of fruit.

"In all cases, each body, whether sound-producing body or fruit-producing body, will produce one kind, and always the same kind, and their product, whether Sound or fruit, or the product of any other producing thing, will be composed of matter, in every case more or less different, gathered and combined by processes which the infinite Creator has established for such purpose. Then must the effect of Sound upon the mind come directly from the substances composing the sound, and the manner in which they are blended.

"And this is as we might expect. For all the effects of fruit, or vegetables, or grain, or any material thing which by contact influences the soul, come from different combinations of matter introduced into the body.

"Why this similarity? Because, as Ellen thinks, the same laws control in each. Each different body makes a different sound; and each different tree raises a different fruit. Always the same body makes a similar sound, and always the same tree yields the same fruit. Certainly in these respects similar laws control them.

"As regards the trees, or any bush, or any flower, we know that the fruits of each and all are composed of different elements of matter, brought together and united by the machinery of the trees and flowers.

"In a precisely similar method, we know that the sounds of all sounding bodies are composed of different elements aroused and combined by shock and the machinery of these bodies in which it is made and which become mills for deciding the character of the sound, when it is thrown off by the vibration. Similarly the saw-dust from the lumber is used to create the steam which runs the saw-mill. The sounder, also, in wireless telegraphy, performs two functions, reproducing the signal and tapping the coherer. And so, often, in coal mines the refuse is used for fuel to supply the necessary steam power. And thus, too, logs are sawn into strips by one set of machinery, and turned into different things, as spools, boxes, etc. by very different machinery. It is, indeed, a very general condition in the things which man makes, that they are partly made by certain machinery and finished off by other.

"And thus, because they are compounded of different materials, at least a different mixture of materials, sounds affect mind differently, but are not different in this respect from other things. For this is the one law and only law by which mind is affected in material conditions. And in every case the thing which affects it,—itself composed of matter,—must be brought into intimate relation with the soul, by admission into the body.

"There is no other possible way by which sounds can be heard; nor can there be any mistake as to their nature if thus introduced, provided the sensation of hearing is in normal condition.

"If it is not, artificial assistance can be had by an ear-trumpet or other instrument, all working to introduce more of the same sound into the ear. In failure of vision, glasses are used for a similar purpose. That is, the glasses converge more light to the eye, and the ear-trumpet, megaphone, or other such instrument, more sound to the ear.

"Why, in either case, the sensation of sight and hearing should be improved, Ellen does not know, but she can easily suppose that that substance which produced a sensation might be more efficient when used in larger quantity; for this is a general, if not universal, law of nature."

"But," I asked, "when a bell sounds, does not the copper or metal affect the tone, and the character of the sound?"

"Form and substance must decide, in part at least, the nature of the vibration," she replied, "assuming that Sound or any other substance causes a body to vibrate by circulating within it. For in such case, and that would appear to be what takes place, and indeed, what we have proven to take place, we should expect the movements of the body to depend upon its construction, as well as upon the force that operates it.

"Something certainly gives to every sounding body its peculiar character of sound. With every one it is different. Or, stating things in the order in which they occur, every body so operates on sound circulating in it or through it as to make of it a particular sound, so that always the same or a similar body produces the same or a similar sound,—the same body always the same sound, and different bodies, different sounds. But there may be a few bodies constructed similarly so as to produce the same sound; in which case they are said to have sympathetic or unison vibration, for these bodies, as Ellen has shown, are thrown into vibration by this thing Sound, caused by shock, circulating in them; and this vibration may be used as an index of the kind of sound which this particular machine or body produces.

"Every body under these circumstances will have what may be called its normal vibration; though this is peculiar with certain bodies, especially musical instruments, in this respect, that in different ways they can be manipulated so as to produce different sounds, and some, as air or string instruments, nearly all sounds.

"A universal system would appear to exist for perfecting or making the varieties of things, and every body acts as a machine to produce a particular variety of sound. It is here that the scientists went to pieces, for they assume that vibration makes Sound, when a little careful study shows that Sound, always produced in a body by shock, makes vibration. And on the other hand, each body in which Sound is made, acts as a machine to mould or shape the particles of Sound circulating through it, whence come the varieties of sound. For every hard body, being of different construction, affects these sounds differently.

"In all cases Sound is made by the usual law of combination of matter, as an apple, or a peach; nor does the apple tree, peach tree, or sounding body lend of its own substance to the thing formed; a tree, flavor, and the sounding body, tone. But instead, they act as machinery to make the fruit and make the sound.

"They have nothing to do with the material, except to assist in its mixing. In this respect they are like most machinery—if not all. A cotton, woolen, or silk factory manufactures cotton, woolen, or silk goods, but the goods are entirely made out of the cotton, woolen, and silk. The same would be true if the goods were made of marble, granite, slate, or any kind of stone; or of brass, copper, iron, or any kind of metal; and the same is true if they are made of Sound. They do not partake at all of the machinery of the mills which make them; without this there could not be any goods, but it does not enter into their composition. Here again we reach the principle of the Universality of Natural Law, and thus can interpret the unknown by the known.

"The different kinds of light, or of taste, or of color, follow in the same category. And so it is with everything. This is the way that things are made; the wonderful law of varieties. There isn't any other way to account for the different kinds of a similar thing. From a certain substance, which we call wood, all the different brands of lumber are made; from another which we call brass all the different sorts of brass goods; and so it is of everything.

"It is equally true of this marvelous universe that the different things, and the different kinds of each thing, are like the sands of the seashore, without number. Such is the wonderful capacity of matter for the manufacture of things."

"But how," I asked, "in all this multitude can we tell what is Sound?"

"There is no difficulty," she answered, "for mind is even more remarkable than matter. Of hundreds of thousands of things which come under the category of sounds, we can readily tell them all.

"And so of light; it shades from the violet to the red, by a slight variance in the amounts of the different ingredients. This law of combinations has no limits. Neither does that of varieties.

"Take trees or snowflakes; there are no two alike, but there is no trouble to tell which is the snowflake or which the tree. And so again it is with everything."

"Ellen has got a fine sentence there," I said, "to limit debate."

"Yes," she replied, "she got that from Mr. Plato, whose 'tongue was the pen of a ready writer'; nor, as Ellen thinks, did he make any mistakes in his philosophy.

"And so, it is with the pretty apples and pears; the trees which bear them act as machinery to provide material for the fruit. The leaves do part of this work, the roots much of it, and every part of the tree some. They provide it, sort it, and hasten it up to the fruit; their part is preparing food for all, and dollars for the farmer.

"And so, too, with sounding bodies. They act as machinery to make Sound. But whatever the body, it does no more. And Ellen doesn't know why it should. That it does not may be proven by a graphophone record. The old Pine asked if, 'when a bell sounds, the copper or metal does not affect its tone?' Whether or not any part of the metal of the bell enters the sounds made by the bell, might be quite difficult to answer alone, but it is more difficult to see how the copper can enter the graphophone record which its sounds make; and therefore how copper can help make the duplicate sound, which the record produces. In this case one sound is made by the bell, and the other by the paraffin and wax. This last, too, by an electrotyping process can be transferred to discs, which will repeat very exactly the record thus transferred, but only in connection with shock, made by a new reproducer, adapted to the new record. Evidently here shock is just as necessary for the production of sound as it has proved to be elsewhere, thus sustaining the universal testimony that Sound never occurs without it.

"And this means, however small may be the indentures, or the disc records of same form made from them, they are abundantly large to receive the particles of matter made by shock, and mould them into particular sounds.

"These material bodies which constitute Sound are to us almost immaterial because so small. It should be a big advertisement to the homeopathists. And because they are thus small, the sounds can get around almost anywhere, and are as harmless as doves.

"In the accepted air pulse theory there is nothing whatever to explain the different character of sounds. In any case the sound is supposed to be made by a vibrating body, as a tuning-fork, piano wire, violin string, column of air, or any conceivable vibrating substance, hitting a particle of air, or several of them, from which operation the whole category of sounds, from the infinitely plain to the exquisitely beautiful, is supposed to come.

"Ellen doesn't think that any of those who teach this theory ever considered this; much less have undertaken to explain it, although anything indissolubly connected with any theory worth considering, not to say promulgating, should be fully considered and understood before the theory is advanced. In this case the only explanation of the difference of sounds would appear to be the manner in which one or several particles of air were struck, whether at a right, acute, or obtuse angle. Possibly it would be claimed that the strength of the blow entered into the problem. But the whole thing is so utterly absurd that even, if we did not know how sounds were made, no person of good sense would consider this theory."

"But can Ellen give a more intelligent explanation by the corpuscular theory?"

"Infinitely more," she answered, "as that theory is entirely built upon the known, indeed universal, laws of nature of performing such phenomena, the laws of the effect of matter, not the same matter but different matter, upon mind, when brought in contact with it.

"Ellen would be ashamed if she undertook to teach the nature of any phenomenon, unless she based it upon nature's laws. She has repeatedly reminded the old Pine that the Universality of Natural Law is the key, and the only key, by which we can unlock the secrets of nature, and she knows perfectly well that any hypotheses advanced which do not recognize this are utterly worthless, although demonstrated, as they generally have been, by a lot of mathematics even more worthless than they, because throwing away infinitesimals, which apparently are the principal part of the universe.

"We know from the fundamental laws of nature, which every one can study and learn, that Sound must be corpuscular, composed of infinitesimal particles of matter.

"In no other way is it possible to account for the phenomena, in all their different phases, which take place. And this does account for all of them. And still stronger than this, as Ellen has repeatedly said, it is the method, and only known method in the universe, by which mind is influenced in material conditions. And as the question is how nature does things, and not how Dr. Young, Mr. Huyghens, or any other man would do them, if they were going to make a universe, we are particularly interested in the laws used by nature.

"And this matter enters the body from the material world, a part of a universal system by which not only the body is sustained, but everything that connects with knowledge in man is supplied.

"Ellen will illustrate, again, the nature of Sound from the graphophone, which is able to repeat certain sounds, and this is accomplished by a body made by the original sound.

"For every sound, under favorable circumstances, makes a body (as an indenture of a graphophone record) which, when played upon, can repeat the sound that made it. So also a succession of sounds can make a succession of instruments, indentures, the whole forming what is called a record, which will repeat these sounds in the order made."

"But," I asked, "can it not also cause a body, with unison or the same vibration as the body which made it, to repeat the same sound?"

"It can enter a body having the same or unison vibration," she replied, "with the body in which it was created, and cause this second body to vibrate, the same as it did the one in which it was made, and thus throw more sound into the air. Thus a stream can flow from one pond into another, and thence into a third. Nor does Ellen know why, if the stream was big enough, whether of water or of Sound, it might not continue its course, constantly throwing off water on the earth, or Sound into the air, until the supply was exhausted. But all of this is but the continuation of the life of one stream, whether water or Sound.

"The only way a sound can create another, is indirectly by creating an instrument which can make it. But, as we have seen, this last instrument can only make it when played upon, that is, when subjected to shock. And thus, so far as we know, shock, or friction, is always the immediate cause of Sound. Then follows immediately vibration of the body struck, and again, immediately, sound is thrown off from the body, by the vibration.

"At the same time this sound is thrown off, precisely similar sound remains in the body struck. We know this because we can conduct such sound to the ear without its entering the air, and at the same time, similar sound, thrown off by the same body, will enter the ear by the air, and indeed may have been entering it several seconds.

"From this we know that sound made in such bodies is entirely finished whilst in them. As nearly all different bodies emit different sounds, whilst apparently struck by exactly the same blow, it is certain that in some way they directly assist in making the sound. This might be done at the time of the blow. If so the blow or shock, and body, working together, must produce the sound instantaneously, which is immediately thrown off into the air. Or this sound may be partially produced, at least finished off, so as to be thrown on the market, by separate action of the body struck. Indeed it would appear that this was what took place. Certainly the sound produced by shock cannot make vibration until after it is made, and, when it does, might be changed into, or complete, the sound that is finally thrown off. For, again, the vibration which throws it off cannot act until it is made.

"Ellen thinks this last is what takes place; that the force is created, a force which we would naturally and fairly call

Sound,—infinitesimal particles of moving electrical matter,—by the blow or shock. That this instantly throws the body into vibration there can be no question, by which, or in connection with which, the material collected by shock becomes a particular kind of sound, and is thrown off into the air, or can be conducted away by many different bodies. For it is full of ambition to travel, and isn't at all particular what route it takes."

"But cannot Ellen state even more exactly," I asked, "how Sound is made?"

"She can more thoroughly illustrate it," she replied. "For these corpuscles of electrical matter, which cause the vibration of the body in which they are made, indirectly may be seen, and vividly so, in the vibration of plates.

"Sir William Wheatstone demonstrated this nearly a hundred years ago, and the great electrician Oersted several years before that. It may be done by covering the top of one of the plates, properly fastened horizontally, with water, and then drawing a bow across one edge. Instantly the water is variegated by a series of crispations, marking the nature of the movements caused by the corpuscles of Sound produced by shock. Their different character is made perfectly evident by the changes in the sound. With the low tones several systems of miniature waves are formed, but as the higher notes are sounded the most exquisite effects are produced in the water, by corpuscles evidently much smaller and in largely increased numbers.

"But why do these corpuscles affect the water?" I asked. "Are they made in it?"

"Not at all," she answered. "They are made in the plate by friction, caused by the bow drawn along its edges.

"Ellen placed her hand upon the plate and could feel that it was permeated with electrical forces—that is, it is permeated with Sound, which causes it to vibrate vigorously; when it does what every similar sounding-body always does, tosses the sound off from it, thus filling portions of the water, those parts lying above the parts where the plate is vibrating, with corpuscles of Sound, which, thrown off from the plate by its vibration, have to pass through the water to get into the air. And these particles as Mr. Wheatstone says: 'vary in magnitude with the degree of tune.'

"And again he says: 'When a more acute sound was produced, the centres consequently became more numerous, and the number of co-existing vibrating particles likewise increased, but their magnitudes proportionally diminished.' And again: 'Diminishing the oscillating part of the plate to one half its length, the double octave to the preceding was heard; four vibrating particles occupying the space before occupied by one, and the absolute number doubled.'

" And still again: 'Let us reduce this half of the plate to half its breadth, and we shall find the note remain the same, but the absolute number of the corpuscles will in this case be equal to that in the entire plate.'

" All of these changes in size and number are plainly visible in experiments made by Mr. Wheatstone.*

"In each case these corpuscles are moving between nodes, thus producing the vibration of the plates, and perhaps at the same time perfecting the particular sound they were intended to produce. This is evidently done by the action of the corpuscles, which themselves are the sound, made by shock,—in this case the bow drawn across one edge of the plate,—and perfected by the plate, or any vibrating body in which they are made.

" We thus get a practically complete illustration of the manufacture of Sound, and can see how all the sounds of the world are made by different bodies, which have a sufficient degree of hardness.

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* See Chapter xxix, page 232.

"Sound, then, can make a body that can do what the original body which made it did; and therefore in certain respects must resemble that body.

"In the illustration that Ellen has taken, let us suppose that the body which began this concert, was a bird or rather the vocal organs of a bird played upon by the bird. In some way, those organs manufactured the sweet notes which, floating in the air, entered a graphophone and made a record. Certainly it was their movement which made it.

"And as we know that they must have been manufactured from material in the throat of a bird, blended or mixed by the machinery of those vocal organs, controlled by the intelligence of the bird, we know that the indentures of this graphophone record represent similar machinery to that of the vocal organs of the bird; for they can reproduce the sounds which those vocal organs produced. That is, they can, if there is anything answering to the intelligence of the bird to manipulate them.

"And here comes in the intelligence of Mr. Edison, to take the place of, or as a substitute for, that of the bird. Thus far, and indeed throughout the performance, the program is furnished by the bird. Mr. Edison had nothing whatever to do with this, though he has had a good deal to do with the machinery at both ends necessary, but entirely secondary, for the experiment. This machinery, we can see, consists of a graphophone instrument by which impressions—forms—created by sound, are made in the grooves of a cylinder covered with paraffin and wax. These forms, called indentures, are the direct result of the song of the bird. They are the only instrument in the concert which can reproduce that song; and, like other instruments, to do it, must be played.

"Again, we know the manner in which the piano furnishes music—some one entirely independent of the piano strikes its keys, which are a part of its sound-producing machinery. These lift a small hammer, which hits a wire, and the shock or disturbance, necessary to the production of Sound, is accomplished. The blow made it in accordance with principles designed by that infinite Being who has constructed every part of this universe, everything in which is but an expression of His thoughts.

"Here the final operation in the production of Sound we believe to be evident. The blow of the hammer upon the wire introduces or makes available the material, quite a part of which at least is electricity, from which the different sounds are to be made; and which answers to the lumber or logs in a saw-mill, or the woolen, cotton, or other material, in other mills, from which the goods are to be manufactured. This material consisting of infinitesimal particles of electrical matter,—called by Mr. Wheatstone, corpuscles,—entering the wire causes it to vibrate or move with great vigor, by which the sounds are perfected and thrown off.

"And now again, by the wisdom of the Creator, the motion that has entered into them from the shock, sustains and carries these infinitesimal particles, so small that they will run up, apparently in large numbers and at the same time, the point of the finest needle,*—in all directions through the atmosphere; and thus are they able to enter the ears of man, and other sentient beings, when, transferred to the mind, they produce the sensation of hearing, and are known as sounds.

"To go back where we branched from the indentures to the piano. Instead of the keys and hammer of a piano, we have the machinery of a graphophone to produce the sound of the record, and this machinery includes the rounded end of the reproducer, by which shock is produced, the body or bodies struck being the indentures.

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[*] See "Ellen," Vol. II., pp. 561, 562.

"With the blow, as always, the corpuscles of Sound are produced, and evidently, though we cannot see it, the usual vibration of the body struck takes place, completing the character of the sound, which is instantly thrown off, and may be heard by listening at the graphophone where the disturbance occurs.

"Up to this, we have had no concert, practically no Sound. But now immediately the air around the indentures is filled with the notes of a bird, and, as the concert goes on, these vary as the bird's song varied. Here all the requisites of Sound exist, an instrument to be played, with arrangements made to play it. And the sound is a repetition of the sound by which the indentures were made.

"And this because the bodies made by Sound, such as those composing a graphophone or telegraphone record, resemble in form the sound which made them, which must have resembled the body which made it. Unquestionably through this principle the record of sound is transmitted to the brain.

"And this means that the sounds of the world, all of them, are made, by the bodies of the world, every hard or so called elastic body making a particular sound; and the same body or a similar one will always make the same sound. This is the universal law that operates in regard to Sound. And therefore there are bodies so made that they will utter the notes of a bird. Such bodies, too, or any bodies, as animals or plants, can reproduce themselves, thus continuing the sounds which they make. But this is not in the ordinary course of things but evidently is especially designed for the records of Sound, though accidentally discovered by man, and used artificially in graphophone and telegraphone records.

"There is nothing strange that this record should sing the song of the bird, or each indenture its part of it, for it's the only song it can sing, the only noise it can make.

"It's the noise it was made to make, and if it sings at all if it makes any noise, it has to make this. It does what every sounding body in the world does, or every sounding instrument, makes the sound it was made to make. And this is true of every material thing; for no material thing has a power of choice. And this sound is the same that the original sounding body made, by which this record was made, precisely the same, and therefore do we know that any sound is the acoustic picture of the body that made it, whether the vocal organs of a bird, or person, or anything else. It is a copy of Sound, made as instantly and accurately as the picture of a landscape by a camera; not any more remarkable than that, but equally faithful, that is, equally perfect, for every part of it is perfectly designed and exquisitely finished. And this copy of a sound, these copies of all sounds, are designed by the same great Artist that made the picture which the camera takes, and the principle by which it can be taken, and that made the sound.

"Is there any person living who supposes that such pictures as these, come hap-hazard, or might be made by a tuning-fork hitting particles of air? If there is, Ellen pities him. Just as well could the finest product in art ever made by a Guido, or a Raphael, be made by a similar blundering performance. The Power which has created everything in this universe made this sound. Ellen knows that if Dr. Young had made a universe, he was going to make Sound out of air by a series of condensations and rarefactions; which in some way never explained, were expected to work together, and carry the correlative of Sound, that is, an accurate copy of the disturbance which made it.

"Ellen doesn't think Dr. Young showed any great genius in his universe; anyway he never got any further with it, although the great body of scientists, who proclaim themselves great admirers of his talents, have been trying since to instruct the youth of the world in his principles of Sound.

It is safe to say that there was never so silly an hypothesis in science conceived as these undulatory theories, whether of Sound or Light; and, as is the case with those carried away by some superstition, or as moths are dazzled by flame, so the votaries of these theories have seemed to be dazed by them.

"And now will Ellen, accepting the principles of Sound made by Him who created the universe, endeavor still further to see exactly in what consists this moving picture of Sound, and how it imparts it to the graphophone record. So far as the mind is concerned, Sound is simply a signal, or signals, to be learned in order to be used. Nor does Ellen understand in what way a combination of matter, infinitesimal or otherwise, affects mind or spirit, when brought into its immediate presence. But she knows that it does, and she knows it is the only way in which mind is affected or educated whilst in material conditions. And she can perceive how the moving sound, operated by electricity, creates an indenture with the same form that the body had which made this acting sound; for this is what takes place. That is, it has manufactured an instrument, diminutive in size, it is true, but which produces the sound that made it.

"It does this as a mould will reproduce in form the thing that made it, and with the same certainty, for with conditions favorable it cannot help but do this. As Ellen has had occasion repeatedly to say of material things, it cannot help but make the thing it was made to make; and so, too, the thing it was made to make, properly played upon, cannot help but repeat the sound which made it, that is, do the thing it was designed to do. This is the one and only principle which makes a Universe possible.

"To repeat, Sound, consisting of infinitesimal particles of moving matter, is started by shock. It has a power of movement varying from about 1040 feet to 16000 more or less per second, depending upon the track in which or on which it travels; and this rate of speed it holds evenly throughout its known existence.

"This sound is moulded, as we have seen, into different forms by the bodies in which it is made, through which it circulates, and which it causes to vibrate. Thus prepared it becomes the sound of commerce, and thus enters a graphophone, a moving piece of machinery, fitted to make and making instruments whose forms are the same as those of the bodies by which these sounds have been uttered; and therefore producing the same sounds.

"In such case Sound is two things: it is Sound, and it is machinery capable of making or preparing an instrument which can be used to make a sound similar to itself. To do it the sound must either by itself, or through the reproducer operated by itself, make a body, an indenture, which, when struck, has the same vibration as the body which made the sound. And this is done by motion, the motion of the sound, which is a power of special movement imparted to it when created, and continuing throughout its existence. When we remember how all plants and animals are made to recreate themselves, there is nothing particularly extraordinary in this. Nor is it any more remarkable, or perhaps as much so, as that a camera can make a picture exactly similar to the landscape which lies before it.

"Size, evidently, the size of the indenture or the body created, is not essential. The one thing important is that the duplicate body made by the sound, in this case the indentures, should have the same forms with the bodies by which the particular sounds were shaped which made them. And therefore when these indentures so made, or others made from them, are struck, they create the same sound or sounds as the instrument or substance after which they are modeled. As two pianos, or any two similar instruments, will produce the same sound, or any two apples, or other fruit of the same kind, the same taste or the same odor. And all of this that refers to Sound takes place because the bodies uttering the same, that is, similar sounds, are of the same forms. It is the principle illustrated by unison vibration, which causes the graphophone record to utter back the sounds which made it. Ellen knows that substantially this is what occurs, and explains fully this phenomenon."

"But exactly what is it that Ellen calls the normal vibration?" I asked.

"Normal vibration is that which infinitesimal particles of electrical matter, aroused by shock or a blow, produce in a body. The same vibration, in whatever body it exists, always accompanies the same sound, for it is made by the sound, one of its purposes at least being to throw it off; but, as Ellen has shown, the material produced by the blow, and which perhaps might fairly be called Sound, as logs are called lumber, in passing through the body is itself changed, and thus we have the varieties of sounds, corresponding to the differences of the bodies in which they are made.

"And this is accomplished through the power of the machinery in each case to combine certain elements of matter; varying with the character of the bodies in which and by which they are combined. Not because such body, or part of it, enters directly into the combination which produces Sound, for it does not, but because the character of the body helps decide, and in certain respects entirely decides, the quality of the sounds it emits, and this, directly or indirectly, through the elements which make it. For every material thing, whether a loaf of bread, a rock, a tree, or Sound, is a combination of matter. Its excellence, too, depends in part upon the mixing, as well as upon the things mixed; the same as provisions depend upon the cooking as well as upon things cooked. And the excellence of this manufacturing must depend upon the excellence of the machinery which makes it. But nature's machinery is always the best possible, and so, too, is the material which she uses; whence come the exquisite colors of the clouds, and the lovely verdure of the forest.

> "Behold the lilies of the field how they grow; they toil not, neither do they spin:
> And yet I say unto you, That Solomon, in all his glory, was not arrayed like one of these."

"And so sounds, though we do not see them, will rival in their tones the beauty of the clouds, or the perfection of flowers in both color and form. The lark soars, and pours forth his melody.

> "Bird of the wilderness, blithesome and cumberless,
> Sweet be thy matin o'er mountain and lea."

"Does the old Pine suppose that there is any other law by which all these things are made? Is there any reason why there should be? There certainly is not; and there certainly is no other law. This, together with the original matter supplied, and the Spiritual or Intellectual Power which supplies, completes existence.

"But the last is practically all. That is, it is the inexhaustible source of supply, making whatever else there is, or whatever else is needed, and therefore, as Bishop Berkeley suggested, it includes the whole.

"Man can manufacture many things, or furnish the machinery to make a glass of soda water; and so Nature by mixing different ingredients, has arranged to make all the odors of the world, all the flowers, all the pictures, all the fruits, all the vegetables, all the animals, all the shells, all the stones, all the soils, all the metals, and indeed every material thing; the sound of the world, as well as its pictures, included.

"We quote again from the article on odors by M. Papillon:

'The quality is of so little importance to Nature, that, while following always the same laws, and constantly using the same materials, she can *by merely changing the ponderable relations of the latter, produce by myriads of various combinations, myriads of substances which have no resemblance to each other.*'"

"But cannot Ellen explain more accurately," I asked, "the distinction between the functions of shock and vibration?"

"Sound," she answered," is composed of infinitesimal particles of moving matter, the difference of sounds, like that in all material things, depending upon the different materials used, and different proportions in which they are taken.

"The sound caused by shock is unquestionably responsible for the vibration of the body in which it is made, and this vibration in the nature of the case also becomes an index of the action of the sound which made it; and therefore it is natural to speak of the vibration making the sound, when as a matter of fact the sound in its essential nature is independent of the vibration, although, when thrown off, the finished product of the action of the vibrating body. Very similarly lumber is independent of the mills which shape it.

"This is somewhat of an intricate proposition, although when carefully thought out it becomes simple enough, and is constantly illustrated in the economies of man.

"Thus what is true of the different kinds of lumber is equally true of every kind of goods; woolen, cotton, silk, or those from any kind of metal, or any kind of stone. It would appear to be true of everything where varieties of things are made from the same material, which is a constant occurrence.

"It is indeed the law governing varieties of things which are formed from the same or similar material; a condition which is universal in creation. In such case the differences may depend entirely upon form, as they would appear to in the different kinds of lumber, or they might depend upon the mixture of different materials, as in goods, or unquestionably also in Sound.

"Thus certain machinery will combine different materials as silk and wool, or cotton and wool, or it may make goods from one material, as silk, or wool, or cotton. But in all cases the same machine or machinery, other things being equal, will make the same goods.

"And thus with sounds, material largely electrical is provided for their manufacture.

"Bodies in which this is made act as machinery for the manufacture of Sound, and every different body will make a different, but similar bodies the same, sound.

"This difference must depend upon the ingredients, and amount of each ingredient in the completed sound, the electrical principle existing in all Sound."

"Then Ellen thinks, to the material made by shock, other material is added, as this is subjected to the machinery of the body, with its remarkably active vibrations?"

"The sound appears to be made instantaneously," she answered, "but undoubtedly there is time enough, and certainly force enough, for any desirable ingredient to be added. But this is certain, first, that Sound is always started by shock; second, every different body makes a different sound, or rather,—for shock is only possible where there are two bodies,—any two hard bodies colliding make a sound, and the same two bodies always the same or a similar sound, but either hitting another, a different sound, although the continued sound of a musical instrument remains the same.

"That is, any particular body when struck by a second body will make a particular sound, and always if struck by this same body, a similar sound; but always, too, when struck by another and different body, the sound of the collision is different.

"It follows that each of the two bodies which cause the shock contribute to the character of the sound.

"This also is certain, that always, as proven by Mr. Wheatstone's experiments, Sound is composed of infinitesimal particles of moving matter, and as proven by Mr. Oersted these particles are electrical. Always, too, these particles of matter throw into vibration the bodies in which they are made, and always by this vibration they are thrown off more or less into the air, a finished article, designed to accomplish the sensation of hearing in all sentient beings, and distributed free, like water, air, or light, for the benefit of all."

"And is this sound entirely completed whilst in the sounding body?"

"It certainly is," she replied, "for we can conduct it from the body to the soul, independent of the air, and know it to be the same sound which comes from the body by the air into the ear."

"And it always originates in shock?"

"It certainly does."

"And the particular sound it represents always depends upon the particular body or bodies in which it is made?"

"Again it certainly does. That is, the same sound is always made by the same or a similar body."

"And there is no other way to make it?"

"None whatever."

"But how does shock make it?"

"By mixing matter; perhaps, more correctly by supplying electrical matter. The same as a glass of lemonade is made, and every other thing that exists in this material universe. Thus, as Ellen has repeatedly said, there is no other way to make any material thing."

"And what makes the differences in the sounds?"

"The different combinations of matter. Every possible difference in sounds comes from this, as every possible difference in food does, or in any other material thing with which we have acquaintance, or which exists."

"And what makes these different mixtures?"

"The different machinery employed to mix them; and after that the laws of God."

"Then Ellen thinks that every sound is finished in the body where it is made, by the mixture of ingredients at command within that body, and by the machinery of that body?"

"As started by shock, yes. But the machinery of that body couldn't work any more without the force aroused by shock, than an engine could without the force aroused by steam, or some other motive power."

"And Ellen thinks that the vibrations of these bodies are a part of the forces which do the mixing?"

"Yes," she answered, "And these must depend more or less, upon the material of which a body is constructed, its form and consistency; indeed everything which combines to make a body what it is."

"But the material of which the machinery is made, does not combine with the thing it mixes?"

"There is no reason why it should," she replied, "and generally as Ellen has said, it does not."

"Of what then are sounds composed,—that is, what substances?"

"We have seen," she answered, "that odors are composed of oxygen and hydrogen, with perhaps some nitrogen added.

"Air is composed mainly of oxygen and nitrogen, in the following weights:

Oxygen, -	23.01
Nitrogen, -	76.99
	100.00

"Water consists of two volumes of hydrogen gas, and one of oxygen, proportion by weight:

Oxygen, -	88.9
Hydrogen, -	11.1
	100.00

"We have seen, that the intensity of Sound depends upon the density of the air where it is made; and also when made in water it is much more intense than when made in air; which makes it reasonably certain that Sound is composed largely of oxygen mixed with electricity, which last gives to it its power of movement, an absolutely essential part in order that it might perform the purpose it was made for, delivering signals to sentient beings.

"The varieties of things are made, as all other things, in accordance with law. That is, there is some cause why certain things are said to be varieties of some other thing. Thus we have varieties of trees, varieties of people, varieties of houses, or of barns, varieties of flowers, and varieties of different flowers, varieties of fruit and varieties of different fruits. Ellen might go on indefinitely, but this is evident, that what makes varieties is the fact that, in certain marked qualities, these varieties are alike.

"Thus in the different varieties of fruit, all, in certain respects, it may be shape, or taste, or both, but in some quality certainly, and perhaps Ellen should say qualities, are very much alike. And this is universally true. Of almost everything, there are varieties, and always varieties of the same species are closely related. It would be impossible otherwise that they should be considered as belonging to the same species.

"But, as all know, there are many varieties of Sound. Then must there be some particular quality or qualities in which they all partake. What are these? Ellen thinks again that the answer is very plain. They all are used in the function of hearing; and they all have the same speed. Then to a similar extent must they have been created by the same causes; and so, too, wherever they differ, the causes must be different. That is, that which made them alike must be the same, and that which made them different must be different. For always the same effect comes from the same cause, and different effects from different causes.

"And this would appear to mean that shock, in its nature always alike, produced those qualities in which sounds are alike; and the different bodies in which they circulate are the causes, of their differences.

"This is equally true in the case of lumber or any goods. The different things made from lumber or other goods are the product of different mills, but the material of which they are made, the wood, the cotton, the silk, have very different origin; nor is it possible that in either case this should be otherwise.

"Man makes the saw-mills, and the other mills, which shape different materials into many varieties, for the use of man. But nature has prepared the material from which Sound is made, and also the mills by which each individual sound is determined; the uses of Sound being not for man alone, but for all sentient beings.

"And Sound always consists of infinitesimal particles of moving matter, made by shock, and always this, whatever particular sound it may represent, moves with the same speed, and performs a similar function.

"But the character of each individual sound depends also upon the instrument or body in which it is made, very similarly, as the character of the lumber depends upon the particular mill by which it is shaped.

"And this Ellen would say of every material thing; for the different things of the universe are numberless as the drops of the ocean. That is, they are numberless to Ellen. But very many of them are made from the same substance, precisely the same so far as we can tell, or very nearly the same in its different variations.

"Thus in lumber they might be made out of a hundred different species of trees, and all of them known as lumber. And so again, as Ellen thinks, it is with everything. For whilst all things are made under a universal system of law and order, no two are exactly alike.

"The same is true of man. He, too, makes everything which he makes out of the same wonderful matter by similar processes. Nor is it possible for him to make anything in any other way.

"It makes physics awfully easy when you find out how they are done."

"And Ellen does not think," I said, "that Sound acting through the principle of unison vibration,—that is, entering another body of similar vibration with the sounding body, and causing it to vibrate,—makes any more sound whilst so doing?"

"Ellen does not," she answered. "How could it? It is shock that makes Sound and there is no shock here. The unison body may retain in part the sound, thus obtained, some little time, and must retain it until it is thrown off, or dies a natural death.

"And the sound will cause vibration in the body or any body which it may enter, having unison vibration with the sounding body. It represents Sound, because it is Sound. But in neither case does it make Sound, for this is impossible without shock."

"But," I said, "can we not hear the sound that it makes?"

"You can hear the sound that it throws off," she answered, "either here or in the body in which it was made. In all cases it will make a body having similar vibration to the sounding body, vibrate. In no case can such vibration make Sound. It cannot make Sound any more than the machinery of a saw-mill can make the lumber which it saws.

"And Ellen is quite inclined to think that the only difference between a unisoh body and any other body in receiving Sound, is that Sound entering a body having unison vibration is able to make it vibrate, because able to circulate in it, or through it. This vibration throws the sound into the air, thus making it audible; whilst a non-vibrating body, although Sound enters it freely as a conductor, is silent because, and simply because, it has no way, by vibration or otherwise, of throwing the sound off, so that it can reach the ear.

"Ganot says:

> 'A singular property of bodies in a state of vibration is that of setting in vibration bodies at rest. Thus, if two tuning-forks, tuned so as to give accurately the same note, be at some distance from each other, and one of them be sounded, the other will be set in vibration and emit the same note. But, if one of the forks be put slightly out of tune with the other, by attaching a piece of wax to one prong, for instance, then the excitation of either one will have no effect on the other.
>
> 'This phenomenon, that a body in a state of vibration has the power of causing an independent body at rest to vibrate in the same period, is called consonance.
>
> 'If a metal wire freely suspended in the air be tightly stretched and then be set in vibration, the note which it emits will be feeble. So, too, a tuning-fork when sounded gives but a feeble note; but if its stem be held on a table the note becomes far louder.
>
> 'The reinforcement of a sound by attaching the sounding body to a large, dry, elastic wooden plate, called a sounding-board, or to a wooden box surrounded by air, is called resonance.'

"In this case Sound made by shock, conducted to the sounding-board, is thrown off into the air in large quantity and probably by the vibration of the board.

> 'Although the terms consonance and resonance are sometimes used indiscriminately, there are distinctions between them.
>
> 'Consonance is the excitation of an independent body to vibrate in unison with the sounding body; it begins later than the sounding body, and continues after it has become silent. Resonance begins and ends with the sound of the exciting body.'

"Sound is always an independent stream created by shock, as much as rain is by clouds, or streams by springs, thus entering the sounding body with the capacity of flowing rapidly, provided it can find a channel to flow in.

"Not finding this its action makes the sounding body vibrate, thus constantly throwing off some sound into the air, where it instantly finds channels in all directions. What cannot thus escape is held in the sounding body, similarly as water is held in a pond which has no outlet; or is partly held in one that has.

"If now the stream of Sound in the sounding body is connected with any channel through which it can flow, it will enter this as rapidly as it can, being conducted by it until it has all left the sounding-body. Frequently it is thus conducted to sounding-boards where it is readily thrown off into the air. Occasionally it finds bodies having the same vibration as the original sounding body, in which case, entering, it causes them to vibrate, because its particles of sound are fitted to circulate in them. This it will do, can't help but do, whilst it lasts, or if reconducted quickly enough to the original sounding-body it would again cause that to vibrate. For these are the things it is made to do, and, given any opportunity, it will continue to do them; but it cannot make any new sound, nor can anything except shock. And therefore in order to have more sound we must have repeated shocks, just as in order to have more rain we must have repeated showers.

"Ellen will now call attention to those things which do take place in the repeating of sounds, and those that do not.

"Sounds are repeated by a graphophone, in accordance with the laws governing Sound. They are not repeated by a diafram, with reason enough, that they could not be without violating these laws, something that never happens, excepting in text-books.

"In one case there is an instrument made, that in strict accordance with the laws governing Sound makes them. In the other there is no such instrument; and the diafram couldn't repeat the sounds of the world, any more than a pumpkin could, or a beet, or a carrot, or anything else which was not made to make them.

"The diafram assists, as Ellen has repeatedly said, in gathering and reflecting Sound, as a stove does heat.

"A writer in "Good Works," 1878, page 280, in a long and ably written article on the telephone and graphophone, in referring to the latter, says:

> 'Once more rotating the cylinder the style rises and falls as the now embossed foil passes beneath it, and the motion given to the style is communicated to the disc and thence to the air around.'

"And Ganot says:

> 'When this record was passed again beneath the style the varying indentations on the foil caused the style to vibrate as it did when it produced the indentations, and the diafram was similarily set into vibration, and reproduced the sound by which it was in the first instance set into vibration.'

"Nothing of the kind takes place. What takes place, as we have seen, is the reproduction or reappearance of the original sound, with its peculiarities and characteristics. And this is infinitesimal particles of matter, endowed with a power of motion. The sounds are made only by the record, as may plainly be demonstrated by listening. They are generally conducted from the record to the diafram, and through this into the megaphone, which introduces them where they are heard.

"That the cause of reproduction of sound in a graphophone is entirely connected with the record, may be tested by anyone. For the sound can be heard when a reproducer is passed over the record, although the record is entirely disconnected from the diafram. Ellen destroyed the diafram but the sounds were reproduced, the style being pressed down upon the record.* All any diafram can do, is to assist in collecting and by that means increasing the effects of sounds made by some sound-producing instrument.

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* The above experiments showing that the only function of a diafram connected with sound is to collect and reflect it, as a stove, heat, were made by Prof. T. E. Boyce, now of Middlebury, Vt., for nine years Professor of Mathematics, Middlebury College, a gentleman unusually accomplished and accurate in all such experiments; together with the author of this book.

"That the repetition of Sound, the same sound by a second body, is strictly a matter of form, is demonstrated by the disc record made from the graphophone record. Through an electrotyping process, a fac-simile copy of the indentures is obtained, which copy is transferred by a pressure of ten tons to new discs, and these, with a reproducer to match, will repeat very perfectly the sound uttered by the first record. The slightest variation in form of the electrotyped record would mar the result.

"It is the same old story, cause and effect, existence and decay. For Sound is a material thing. But the soul is immortal and never dies; as Ellen has shown, it only changes from one phase of existence to another."

"And Ellen has also lifted the glamour off from Sound," I said, "and left it as clear and open as a crystal stream."

XXIX.

BEFORE closing we will refer to an article by Sir Charles Wheatstone on Sound, published in the Annals of Philosophy, London, 1823, in which he gives a full description of the discovery of the corpuscles of Sound in certain experiments made by him, connected with the vibration of plates. Mr. Wheatstone also refers to conversation with the very able Danish scientist Oersted, who said that he had a number of years before made the same discoveries, which he published in Lieber's History of Natural Philosophy, 1813. This last book is not in the Congressional Library at Washington, and we have not been able as yet to secure it. Mr. Wheatstone, whose "Enchanted Lyre," exhibited at London several years, had given him much prominence in the discussion of Sound, begins his article as follows:

"Before I enter on the immediate subject of this article, it may be necessary to exhibit a general view of those bodies, which, being properly excited, make those sensible oscillations, which have been thought to be the proximate causes of all the phenomena of sound. These bodies, to avoid many circumlocutions otherwise inevitable, I have termed Phonics.

LINEAR PHONICS.

TRANSVERSAL.	LONGITUDINAL.
Making their oscillations at right angles to their axis:	Making their oscillations in the direction of their axis:
1. Capable of tension, or variable rigidity: chords or wires.	1. Columns of æriform fluids or liquids: cylindric and prismatic rods.
2. Permanently rigid: rods, forks, rings, etc.	

SUPERFICIAL PHONICS.

1. Capable of tension: extended membranes.
2. Permanently rigid: laminæ, bells, vases, etc.

SOLID PHONICS.

1. Volumes of æriform fluids.

"The sensation of sound can be excited by any of these bodies, when they oscillate sufficiently rapidly, either entire, or divided into any number of parts in equilibrium with each other.

"The laws of these subdivisions differ in the various phonics according to their form and mode of connection or insulation; and the velocities of the oscillations, or degrees of tune, depend on the form, dimensions, mode of connection, mode of division, and elasticity of the body employed. The points of division in linear phonics are called nodes, and the boundaries of the vibrating parts of elastic surfaces are termed nodal lines. The part at which the oscillatory portions have their greatest excursions are named centres of vibration; these are always at the greatest mean distances from the nodal points or lines.

"*These mechanical oscillations are not however, themselves, the immediate causes of sound;* they are but the agents in producing in the bodies themselves, and in other contiguous substances isochronous vibrations of *certain particles varying in magnitude according to the degree of tune.*"

Here is a full perception that there are "certain particles," infinitesimal, as we all know, varying in magnitude according to the pitch. All of which is correct, and had Mr. Wheatstone added, "which particles are Sound," he would have relieved the world of a vast amount of ignorance, establishing in its place a perfectly lucid explanation of the phenomenon of Sound.

For if the rubbish that has covered it is removed, the phenomenon is as simple as anything can be. The sound is made by shock, or friction, adapts itself immediately to the body in which it is made, and circulates in it, being itself molded into form, the different ingredients mixed after the one law for the creation of material things, and thrown off into the air by the force of their own movement; or, when opportunity is presented, following different conductors.

We have shown by experiments of Prof. Henry of the coast survey, at Washington, that with a pine board conductor the sound could be emptied from a fork in ten seconds, which, hung by a cord in air, would vibrate 252 seconds; that is, over 25 times as long.* And this operation is spoken of in science as the transmission of the vibrations of the tuning-fork; a phrase exceedingly stupid, because entirely meaningless. In all such cases what is transmitted is Sound, which, given a channel, will run off as water from a pond, and when conveyed to sounding bodies is thrown off into the air, by their very greatly extended surface, in largely increased quantity, and, thus aggregated, entering the ears of sentient beings, produces a louder sound by the universal law of increased effects from increased amounts.

This result is accomplished, too, by a megaphone, or any instrument which gathers Sound in increased quantities, and, thus massed, sends it in the direction of the hearer; and, to any one using good sense, is a complete demonstration, in itself, that Sound is corpuscular.

It will be noticed, too, that Mr. Wheatstone says: "These mechanical oscillations are not however, themselves the immediate cause of sound," which is a distinct denial of the undulatory theory of Sound. For these mechanical oscillations by that theory are the cause, and only cause, of Sound, the theory being that musical instruments and presumably other bodies by vibration, hitting particles of air, produce "sonorous waves," which, with scientists, is another name for Sound.

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* See Ellen, Vol. II., page 555.

Mr. Wheatstone further says:

> "When a more acute sound was produced, *the centres consequently became more numerous, and the number of co-existing vibrating particles likewise increased, but their magnitudes proportionally diminished.*"

This again refers to the particles of Sound made by shock, as is easily demonstrated by experiment. For as the sounds produced are raised in pitch, it is most noticeable that these corpuscles are diminished in size, but increased in numbers, which Mr. Wheatstone shows is done according to the rules.

Always in this material universe things which have successive causes take place successively. It makes no difference how instantaneously may be the whole transaction. Often it is so instantaneous, that it is impossible for us to perceive the succession. Thus with light, the ray reflected from the obiect to the eye, and which makes the picture of the object in the eye, always touches the object before it does the eye. This we know, with absolute certainty, from the nature of things, although the ray moves at 184,000 miles a second, and therefore its successive positions cannot be followed at all by our eye And so with Sound, always the shock precedes, and always, next, the corpuscles are formed by which, instantly, the body in which they are formed is thrown into vibration, when these corpuscles become a particular sound, and are thrown off by the vibration. It would be impossible for the order to be reversed, although it would be equally impossible for us to follow it with the eye.

It very frequently happens that physical vision cannot keep pace with movement, and thus, often, error arises, which might be entirely avoided if the mind's eye, instead of the physical, was used. For Thought in its speed can distance every material thing.

" The sounds of elastic laminae are generally supposed to be owing to the entire oscillations of the simple parts as shown by Chladni, when, by strewing sand over the sonorous plates, he observed the particles repulsed by the vibrating parts, accumulate on the nodal lines, and indicate the bounds of the sensible oscillations. Did no other motions exist in the plate but these entire oscillations, the water laid on its surface would, on account of its cohesion to the glass, show no peculiar phenomena, but the appearances above described clearly demonstrated that the *oscillating parts consist of a number of vibrating particles of equal magnitudes, the excursions of which are greatest at the centres of vibration, and gradually become less until they become almost null at the nodal lines.*

" To multiply these surfaces, and to observe whether the magnitudes in these particles vary in different media, in a glass vessel of a cylindric form, I superposed three immiscible fluids of different densities; namely, mercury, water, and oil. On producing the sounds corresponding with each mode of division, I observed a number of vibrating parts, agreeing with the sound, and showing similar appearances to the plate, formed on the surfaces of each of the fluids; not the least agitation appeared in the uniform parts. I afterwards inserted this glass in another vessel of water in order to observe the vibrations of the external surface, and found the same results as in the interior, though the levels of the surfaces were different."

That is, from the repeated experiments, it was shown that the cause of these corpuscles was neither the mercury, water, or oil in the cylindric glass vessel, or the vessel of water in which this cylindric vessel was inserted, but was the sound made by the bow, and varying with the pitch in accordance with the rules of Sound.

> "The most accurate method to observe these phenomena is by employing a metallic plate of small dimensions, which must be fixed horizontally in a vice at one end, and covered on its upper side with a surface of water: on causing it to oscillate entirely by means of a bow, a regular succession of these vibrating corpuscles will appear arranged parallel to the two directions of the plate, and if the action of the bow be rendered continuous, their absolute number might be counted with the aid of a micrometer."

This means that when the object is seen through a microscope, the number of particles can be counted that correspond to a certain length of the micrometer scale, and thus the number corresponding to one inch or any other interval may be known.

> "Diminishing the oscillating part of the plate to one half of its length, the double octave to the preceding was heard, agreeably to the established rule, that the velocities of the oscillations are inversely as the squares of the lengths; four vibrating corpuscles then occupied the space before occupied by one, and the absolute number was double to that in the former instance; but the absolute number of these corpuscles have no influence whatever on the degree of tune, which entirely depends on their relative magnitude in the same substance; theory shows us that in plates of this description alteration of breadth does not affect the degree of tune; let us, therefore, reduce this half of the plate to half its breadth, and we shall find the note

remain the same, but the absolute number of the corpuscles will in this case be equal to that in the entire plate. Let us now take two plates of equal lengths and breadths, but one double in thickness to the other; the rule is, that the velocities of the oscillations are as the thicknesses of the plates; we shall, therefore, in the thicker plate see a double number of particles to that of the other, occupying the same extent of surface. The last circumstance in which two plates may differ is their specific rigidity, and in this respect it will be found that two plates of exactly equal dimensions, and covered with the same number of vibrating corpuscles of equal magnitudes of the hypothetical particles, cannot be assumed as a standard of tune, unless regulated by the specific rigidity.

"Unassisted by any means of actual admeasurement, the above are but the proximate results sensible to the eye; more extended and accurate experiments are necessary to confirm the results with mathemathical certainty. As the absolute magnitudes of these particles will, I imagine, be hereafter a most useful element for calculation, I will here indicate the most effectual way I am acquainted with to arrive at this knowledge. A thick metallic slip of considerable length and breadth, bent similarly to a tuning-fork, and fixed at its curved part in a vice, is very easily excited by friction, and a more considerable surface of regularly arranged vibrating particles is seen than in most other superficies; any description of common exciter may be employed. When this bent plate is excited by percussion, the particles, before their disappearance, will assume an apparent rotatory motion, on account of the force exerted, and its susceptibility of continuing the vibrations. Employing a parallelopedal rod, the appearances of the higher modes form ellipses, and the semi-part at the free end, a regular half of the same figure. It is important to remark, that the crispations of the water only appear on the sides in the plane of oscillation; the other two sides, on one of which the exciter must be applied, do not show similar appearances.

"I have also rendered the phonic molecular vibrations visible, when produced by the longitudinal oscillations of a column of air; the following were the means employed: I placed the open end of the head of a flute or flagiolet on the surface of a vessel of water, and on blowing to produce the sound, I observed similar crispations to those described above, forming a circle round the end of the tube, and afterwards appearing to radiate in right lines; *on the harmonics of the tube being sounded, the crispations were correspondently diminished in magnitude.*"

It is certainly most remarkable, that having discovered the particles of Sound in their different varieties, according to the pitch or tone, practically a disclosure of the whole theory, neither Mr. Wheatstone, nor anyone else was able to announce it, that is, to get out of the rut into which most foolishly they had been led by incompetent leaders. And thus, this most important knowledge for nearly a hundred years has been lost to the world.

"These phenomena will be more evident if the tube be raised a little from the surface of the liquid and a thin connecting film be left surrounding it; the vibrating particles will then occupy a greater space, and be more sensible.

"The existence of the molecular vibrations being now completely established, it becomes a critical question, in what manner the sensible oscillations induce these vibrating particles.

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"To avoid confusion, I have restricted the word vibrations to the motions of the more minute parts, and the term oscillations to those of the sensible divisions. We may reasonably suppose that the molecular vibrations pervade the entire substance of a phonic; their excursions, however, are not the same in all parts, and they can only be rendered visible, when these excursions are large; they may be so few in number as to be entirely inaudible, as in their transmission through linear conductors; but however few, when they are properly directed, they induce the mechanical divisions of sonorous bodies, each of which will give birth to numerous vibrating corpuscles whose excursions are greater, and the sound will be rendered audible. Dr. Savart has well investigated the modes of division in surfaces put in motion by communicated vibrations. All those phonics whose limited superficies preclude them from exciting in themselves a sufficient number of vibrating corpuscles, when insulated, produce scarcely any perceptible sound, as extended chords, tuning-forks, &c., but those whose superficies or solidities are more extended, as bells, elastic laminæ, columns of air, &c. produce sufficient volume of sound without accessory means.

"Loudness of Sound is dependent on the excursions of the vibrations; volume or fullness on the number of co-existing particles put in motion. Thus the tones of the Æolian harp, on account of the number of subdivisions of the strings, are remarkably beautiful and rich, without possessing much power; and the sounds of an Harmonica glass, in which a greater number of particles are excited than by any other means, are extraordinarily so united, according to the method of excitation, with considerable intensity; their pervading nature is one of the greatest peculiarities of these sounds.

"The following is a recapitulation of the various properties of Sound, which are attributable to modifications of the vibrating corpuscles:

The tune	Depends on the	velocities of the vibrations.
The time		continuance of the vibrations.
The intensity		excursions of the vibrations.
The richness, or volume		number of co-existing vibrations.
The quality (timbre)		magnitudes of the vibrating corpuscles.

"It has often been thought necessary to admit the existence of more minute motions than the sensible oscillations, in order to account for many phenomena in the production of sound. Perrault in his 'Essai du Bruit,' insisted on their necessity more than any other author I have read: he imagined, that the vibrations have a much greater velocity than the oscillations which cause them, but the experiment he adduced to prove this is far from conclusive; he mistook for these vibrations the oscillations of the subdivisions of the long string he employed. Other distinguished philosophers have had ideas of a similar nature, and Chladni thinks their existence necessary to account for the varieties of quality. I, however, conceived I was the first who had indicated these phenomena by experiment, until a few days ago repeating them, together with the others which form the subject of this paper, in the presence of Prof. Oersted, of Copenhagen, he acquainted me with some similar experiments of his own. Substituting a very fine powder, Lycopodium instead of the sand used by Chladni, for showing the oscillations of elastic plates, this eminent philosopher found the particles not only repulsed to the nodal lines, but at the same time *to be accumulated in small parcels on and near the centres of vibrations;* these appearances he presumed to indicate more minute vibrations, which were the causes of the quality of the sound: subsequently he confirmed his opinion, by observing the crispations of water, or alcohol, on similar plates, and showed that the same minute vibrations must take place in the transmitting medium, *as they were equally produced in a surface of water, when the sounding plate was dipped into a mass of this fluid.* These experiments were inserted in Lieber's History of Natural Philosophy, 1813.

RECTILINEAL TRANSMISSION OF SOUND.

"As the laws of the comunication of the phonic vibrations are more evident in linear conductors, I shall confine the present article to a summary of their principal phenomena.

"In my first experiments on this subject, I placed a tuning-fork, or a chord extended on a bow, on the extremity of a glass, or metallic rod, five feet in length, communicating with a sounding board; the sound was heard as instantaneously as when the fork was in immediate contact, and it immediately ceased when the rod was removed from the sounding board, or the fork from the rod. From this it is evident that the vibrations, inaudible in their transmission, being multiplied by meeting with a sonorous body, become very sensibly heard. Pursuing my investigations on this subject, I have discovered means for transmitting, through rods of much greater lengths and of very inconsiderable thicknesses, the sounds of all musical instruments dependent on the vibrations of solid bodies, and of many descriptions of wind instruments. It is astonishing how all the varieties of tune, quality, and audibility, and all the combinations of harmony, are thus transmitted unimpaired, and again rendered audible by communication with an appropriate receiver. One of the practical applications of this discovery has been exhibited in London for about two years under the appellation of 'The Enchanted Lyre.' So perfect was the illusion in this instance from the intense vibratory state of the reciprocating instrument, and from the interception of the sounds of the distant exciting one, that it was universally imagined to be one of the highest efforts of ingenuity in musical mechanism. The details of the extensive modifications of which this invention is susceptible, I shall reserve for a future communication; the external appearance and effects of the individual application above mentioned have been described in the principal periodical journals.

"The transmission of the vibrations through any communicating medium as well as through linear conductors is attended by peculiar phenomena; pulses are formed similar to those in longitudinal phonics, and consequently the centres of vibration and the nodes are reproduced periodically at equal distances; in this we observe an analogous disposition with regard to light. I had intended to include in this paper all the analogical facts I have observed illustratory of the identity of the cause of these two principal objects of sensation, but want of time, and the danger of delay, now the subject is occupying so much the attention of the scientific world, have induced me hastily to collect the present experiments, and to defer the others for a future opportunity.

"The thicknesses of conductors materially influence the power of transmission, and there is a limit of thickness, differing for the different degree of tune, beyond which the vibrations will not be transmitted. The vibrations of acute sounds can be transmitted through smaller wires than those of grave sounds: a proof of this is easy; attach a tuning-fork to one end of a very small wire, and apply the other end to the ear, or a sounding board; on striking the fork rather hard, two co-existing sounds will be produced, that which is more acute will be distinctly heard, but the other will not be transmitted. If the vibrations of a tuning-fork be conducted through a piece of brass wire of the size and thickness of a large needle, the sound, imperfectly transmitted, will become more audible by the pressure of fingers on the conducting wire; but if a steel wire of the same length and thickness be employed, the sound will be unaltered by any pressure, because steel has a greater specific elasticity than brass."

Held in the meshes of a false theory, Mr. Wheatstone is still somewhat confused with the idea that the sounding-body is transmitted, instead of Sound He is wholly mistaken that the explanation of these corpuscles not being audible in linear conductors is their fewness. Every particle that is delivered to the sounding-board from the sounding body or bodies, in above concert, passes through the conductors. When spread over the sounding-board they are thrown off into the air, and thus get access to the ears of one or many persons within their reach.

These are inaudible, or nearly so, because they can't, or don't, under the circumstances, get out of the conductor. As they are the sound and only sound in this field, unless in some way they can get into the ear they cannot affect the soul, any soul. But if no sentient being ever existed upon this globe, they are Sound and would affect such, if they could get access to them.

If Mr. Wheatstone had run one of these conductors from the sounding body between his teeth he would have had music enough, and there would have been just so much less at his concert in the upper story.

And you might as well call a brook the vibration of a spring, as Sound the vibration of a tuning-fork or any other musical instrument.

The vibrations of a tuning-fork are the movements of its prongs to and fro; and like everything else in the world, have a cause, *i. e.* a material cause, and this is the disturbance, or shock, which is both something and produces something; the disturbance being a movement of matter, and the thing produced a new kind of matter, Sound, infinitesimal particles of moving matter, which, circulating in the fork, cause its prongs to vibrate.

This Sound will continue to vibrate in the fork, that is, to make it move, or its prongs move, so long as it remains in it, which will be through its natural life, unless it is thrown off by the fork, or conducted away. The throwing off process is a slow one; but it can be conducted, as Mr. Wheatstone shows, by certain kinds of rods connecting with the vibrating part of any musical instrument, as the stem of the tuning-fork, and through these conductors it may be distributed over another sounding-board, similarly as a flowing stream may be conducted from one pond into another.

Because of the comparatively large surface and character of the sounding-board, the sound is transferred rapidly into the air, by which it readily finds its way into the ears of sentient beings, and thus performs the mission for which it was created.

The statement, made by Prof. Tyndall and other scientists, that the vibrations of the tuning-fork, or other instruments, are transferred to the sounding-board, or anywhere else, is utter nonsense, unless the words "vibrations of the tuning-fork" are used metaphorically.

For the Amazon River no more certainly starts upon the lofty peaks of the Andes, because of the disturbances of rain and snow which there take place, than the streams of Sound start where disturbances of bodies take place, and flow through the air or by other conductors, until their mission, which is their life, is ended.

And these streams of Sound just as certainly make these musical instruments vibrate whilst they are in them, as they make the deal stick or other conductor, held in the hand, vibrate—more accurately tremble,—as they pass through it; or, entering the bodily system, impress the soul with their peculiar message.

The streams of Sound are electrical streams of matter, composed of infinitesimal particles of infinite numbers, which have a constant tendency to scatter in independent directions, and do so scatter in air, or elsewhere, unless held in straight line by a conducting body, as in a wire, and always when thus held they break away at a tangent at every opportunity.

All this goes to prove that Sound is electrical, acting in such regards very much as we perceive through wireless telegraphy that electricity does, the amount of space which it can fill alone dependent upon the amount of electricity at command.

And it takes but a little to go a great way. There are limits to the amount of electricity, or sound, or any thing else, needed, and therefore limit to the quantity which exists; the two being with much exactness proportionate to each other.

There follows a closing article on the Polarization of Sound in which again the "transmission of vibrations" is referred to.

In all cases this so-called "transmission of vibrations" is simply the manner in which Sound travels under different circumstances. In every case when moving through a rectilinear conductor all the sound so moving is furnished by the sounding body, or bodies.

The agitation of much sound as it goes through different conductors is often very sensible to the hand holding them, but can only be heard as the sound gets into the air because it cannot otherwise get into the ear. In the experiments made by Prof. Henry at Washington, he found that the same fork, struck in the same manner, which would vibrate 252 seconds when "suspended in the free air by a fine cambric thread," was emptied, if placed upon a marble slab, solid brick wall, and wall of lath and plaster, respectively, in 115, 88, and 18 seconds.

Placed upon a large thin pine board the sound entirely ran out in 10 seconds. In this case Prof. Henry remarks: "The shortness of duration was compensated for by the greater intensity of effect produced."

"Placed on a cube of india-rubber," Prof. Henry says, "the sound emitted by the fork was scarcely greater then when suspended from the cambric thread, but its duration was only 40 seconds. In this case, the sound was neither transmitted through the rubber nor given off to the air; but probably produced a change in the matter of the rubber, or was changed to heat, or both."

Both common sense and the above experiments show that what scientists call "vibrations" are Sound; and the ingenious phrase "transmission of vibrations" which has so successfully deceived the ignorant, and some that ought not to be so ignorant, for many years, is simply the transmission of Sound; which can be transmitted, so long as it continues to exist, by conductors of different material, at a rate varying from 1100 to 18,000 feet per second more or less, or, if assisted by the electric current, whether by telephone, or telegraph, wireless or otherwise 184,000 miles per second, more or less.

XXX.

WE add a translation from "The Mechanical Part of Natural Science" by Hans Christian Oersted on vibrating plates, liquids and tubes, taken from the German edition of 1851, exhibiting with the illustrations the different ways in which these bodies vibrate.

"If a square disc is supported at the middle points of its sides and then stroked at a corner, there are formed nodes as in the first quarter of figure 22. If it is then supported at the corners and stroked at the middle point of its side there will appear a figure as in the first quarter of figure 23, and one can say in general that if two points on a disc are supported the straight line which is drawn between them is a node. It is not necessary, in order to bring out a certain figure, to support all the end-points of the nodes; but it is sufficient to support so many points that a section can not during the stroking vibrate in more than one direction, for in that case the disc will become so

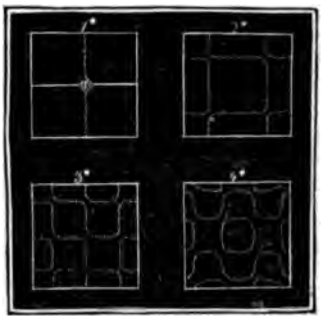

Fig. 22.

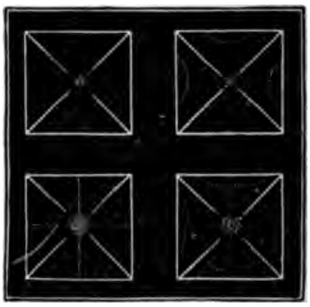

Fig. 23.

arranged that the other parts of the figure appear. So in figure above, it would have been sufficient to have supported the point of intersection of the nodes. How differently through manipulation might be formed the figures of a simple square disc, the following figures will show to describe whose origin would be not very instructive.

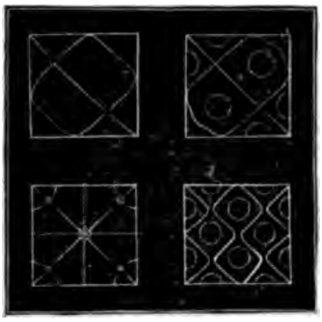

Fig. 24.

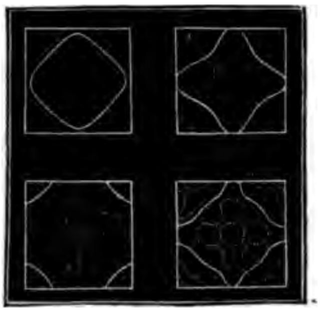

Fig. 25.

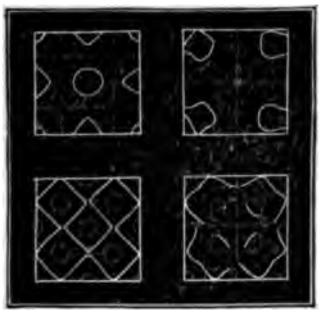

Fig. 26.

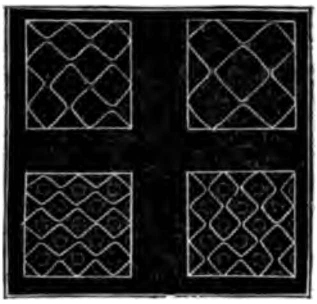

Fig. 27.

"If one supports a circular disc at the center and strokes a place on the circumference, then occur two extremities of the nodes, which become diameters, each about 45° from the spot which was stroked, which results appear equally well if one supports the disc at a point on the circumference and strokes it at a point 45° distant; if one strokes it 30° from the point of support there is formed a star with six points. If one supports it at a distance of n° from the point of support it is divided into $\frac{180}{n}$ parts. If one supports a point within the disc and strokes the corresponding point on the circumference then is formed a node concentric with the circumference of the disc and passing through the point of support. Also on a round disc numberless complicated figures may be produced by special devices as those of figure 28 show.

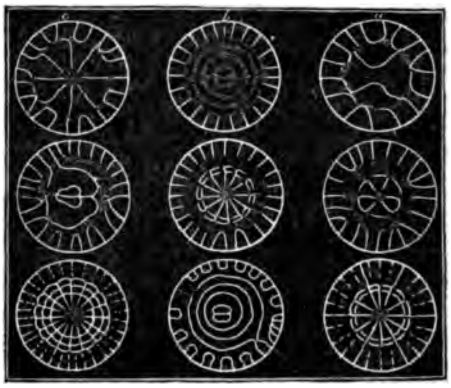

Fig. 28.

"In all these experiments it is evident that the sand not only covers the nodes, but also a part of the space on either side of them, since namely, the parts of the vibrating disc which are near them, and therefore make shorter vibrations, have not enough motion to throw the sand away from themselves. This lack of strength in throwing away the sand becomes even more pronounced near the intersections of nodes where a still greater space remains covered with sand, and that is the reason why the figures never form straight lines, but the sand arranges itself in crooked borders about the nodes, which crooked lines I have discovered to be hyperbolas whose asymptotes are the nodes.

"If one uses for these experiments a finer dust, as for example witch meal (Lycopodium), there appear many movements which are not apparent when sand is used. This is for the reason that grains of sand and other similar bodies are set into such violent motion when they receive the shock of the vibrating plane that they in part, make often repeated leaps and therefore cannot come to rest except upon those places which have a very slight movement; on the other hand each part of the fine dust receives a much smaller amount of the motion, and therefore overcomes the opposition of the air, with more difficulty, or is borne up more by the air and falls with much less swiftness, and finally is affected by those motions in which the air itself is set by the vibrating plane. These complications are all not yet completely cleared up but they deserve all the more to be considered experimentally. If one covers a part of the disc with water or alcohol then there appear these various smaller vibrations which here take place but now on appear as small intersecting waves. If one uses for the figure a metallic-dust with little elasticity, as for example lead filings, then one receives not the finer vibrations which the fine dust showed but the numerous movements of the sand and similar bodies and the lines of dust lie still more distant from the nodes. The path, which the small particles trace on the vibrating glass in order to reach their resting places, one can easily show if he chooses a powder which adheres, to a certain degree, to the glass, and thereby shows its own path. If one pours the powder on only the points of greatest motion, then the particles extend out like beams and equally strong in all directions, in which they find points of rest, and by no means move merely toward the nearest points of rest But these beams are not straight lines but the law of their formation is that their direction at the moment when they intersect the lines of rest is perpendicular to the latter, so that the momentum of the particles meeting from both sides at the line of rest destroys the force of each other.

"If curved surfaces such as bells, glasses (tumblers) and similar objects are set vibrating, there arise likewise nodes which divide the surface into swinging parts. One can show this if he pours water or quicksilver into a large glass, figures 29 and 30, and strokes the rim with a bow. Then the liquid will from several places within the circle be violently repelled and at other places remain at rest.

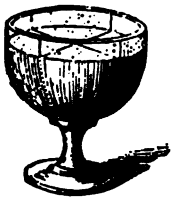
Fig. 29.

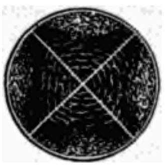
Fig. 30.

"Thin bodies such as paper, bladders, gold-beater's skin, etc., can also show figures. If one stretches these across a wooden frame or bell-jar, covers them with sand or witch-meal and then sets them vibrating by bringing near them a vibrating plate, they will then show a diagram similar to that which the plate itself would give.

"Longitudinal vibrations are produced in a different way, for example with a glass tube 4 or 5 feet long and 3 or 4 lines in diameter, while one holds it firmly by the middle and rubs it with a damp cloth. If one holds the tube horizontally and hangs little paper rings on the half which is not rubbed, then these are moved and first come to rest at the points where the vibration nodes are. If one turns the tube in his hand a little, the rings do not remain at rest in the same places, but are moved to other points. If one marks these different points, then he will see that the vibration-nodes form a sort of irregular spiral line about the tube, figures 31 and 32. The inner surface of the tube

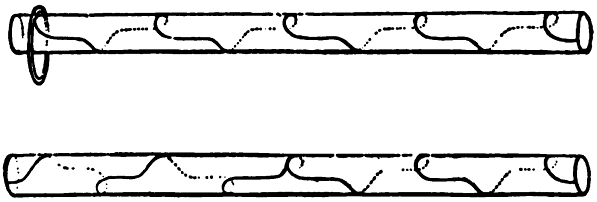
Fig. 31 and 32.

shows a similar line of nodes, which one can find by placing little pieces of cork or wax within the tube.

"If one holds the glass tube vertical he can find the position of the nodes by placing in the lower end a smooth-fitting cork. This will rise in the tube till it finds a vibration-node where it can remain at rest. The force with which the cork is raised is so great that it can lift a column of water which is above it.

"If one connects two circular parallel disks by a glass rod, which is fastened vertically to their centers and then strokes one of them with a violin bow, the same vibrations will be caused in the other plane, and both will form the same figure in sand which is sprinkled on them."

This because glass is a good conductor of Sound. Thus place an inverted tumbler on wooden table; strike a tuning-fork and put stem on bottom of tumbler. Immediately the table is filled with sound from the tuning-fork, showing the tumbler to be an excellent conductor.

"If a metal wire with a suspended weight is twisted about its axis, if the twisting force ceases, it strives to return to its original position. But since on account of the momentum it has acquired, it goes beyond this there arises a series of swings, each of which is completed in an equal interval of time, no matter whether the angle through which it twists be great or small.

"From this it follows that the force causing the movement in such a wire, must at each movement be in proportion to the angle which must be traversed, because otherwise twists of unequal size would not be made in the same time. This, in other words, means that the twisting force varies as the angle of twist."

XXXI.

IN this essay, we have demonstrated in at least a dozen different directions, that Sound is corpuscular, a combination of matter. First, in the nature of things, it would be impossible for it to be otherwise, as this is the one and only method by which mind existing in material conditions is instructed, or in any way provided for.

Second, the hypothesis that particles of air are combined in special form, and move in all directions, representing something that, in its nature, is fixed and unchangeable, is so inconceivably stupid, that we cannot help but doubt whether seriously anyone ever believed it.

We have proven that the idea, universal in text-books of physics, that damage caused by explosions is due to Sound, is entirely incorrect. Any suggestion that damage done by hurricanes, tornadoes, or storms of any kind, is due to Sound, would be equally incorrect. There are plenty of air pulses around at such times, and if Sound was air pulses it would be implicated, but it is not.

We have shown that the theory has been condemned by many able men of the past, including Plato, who is said to have held that Sound was particles of matter, wafted through the air to the soul.

We have called attention to the fact that all the sources of sensations, including odor, and only excepting, by the more indifferent thinkers, Light and Sound, are known to be particles of matter, and that to anyone of good sense, who carefully considers the subject, it is self-evident that the sources of all the sensations are similar. Great truths are frequently so self-evident that it should be impossible to go amiss in regard to them

We have called attention to the absurdity of the explanation made by all scientists of the action of Sound at a telephone, that it is repeated by the diafram of the receiving instrument; offering cash, $1000, to the first person who shall prove it; without, as yet, a single word in response. We have also offered the same to the first person who shall prove that the undulatory theories are true. And both of these offers we repeat here.

The claim that the diafram can talk or repeat Sound, is absolutely without the slightest possible foundation, and inconceivable to anyone who has ever carefully considered the methods employed by nature in the construction of the universe, for it includes the idea that something could make Sound that wasn't made to make it, and hadn't any machinery with which to make it; in other words, ignores the great and universal principle of an appropriate cause for every effect; thus assuming that grapes can be gathered from thorns, and figs from thistles.

Certain so-called philosophers have claimed, and it has been accepted by the text-books, that solid bodies, which they call elastic, are composed of several varieties of particles, the smallest of which they name corpuscles, and that these corpuscles, in case of shock, which produces Sound, although not able to separate themselves, because belonging to solid bodies, are disturbed and in some way cause, how not explained, the body in which they are assumed to be, to vibrate.

All of this is hypothesis and pure romancing. Every body has its normal vibration—the vibration which it would naturally make, if struck or subjected to shock, and not interfered with. Such shock or disturbance always precedes Sound. Immediately with the shock in musical instruments Sound and continued vibration take place. The text-books say Sound is produced by shock or friction; but friction is shock.

The manufacture of Sound is begun with shock or disturbance, and completed by the body in which it is made, which itself acts as a mill to prepare a particular kind of sound. And this is accomplished by the manner in which the material made by shock, that is Sound, circulates in the body, the different lines of its circulation affecting the sound.

The process is a very simple one, beginning with shock or a blow, which creates the Sound—infinitesimal particles of moving electrical matter.

This instantly starts vibration in the body in which it takes place, which body moulds the character of the sound, and when finished,—which is done almost instantly,—throws it off into the air, where, separating in all directions, it performs the functions for which it is made.

As we have shown this method of manufacturing Sound is similar to artificial methods of manufacturing the varieties of things. Material is furnished as lumber, cotton, wool, etc., which the different mills deliver in such form as it is wanted; there being a mill to produce every variety.

And so it is with Sound each variety is produced by a different mill. And many if not all material bodies can be used for such mills. A better system for the production of the great varieties of sounds, necessary in the economy of the universe is inconceivable. Like all of nature's methods we recognize it as the best possible.

It is, too, as a whole quite similar to the operations of a printing press, one of the most ingenious as well as one of the most valuable of the inventions of man.

For here, too, material to be acted upon, blank paper, is furnished to the machine and rapidly passes through it, when, its character entirely changed, it becomes a newspaper, is folded and thrown off; all by the action of the body or machine, which it passes through.

That in nature a similar thing is constantly occurring, although on a much broader scale and with vastly greater results, is certain; for man can only act in accordance with laws which extend throughout the universe; that is, laws created by God. And the law which arranges for the varieties of different things, —in this case the varieties of Sound,—is such, through the great principle of cause and effect.

Thus the invention of the telescope or microscope was accomplished by studying the laws of vision. And as the laws which govern Sound operate equally in large bodies and in small, so those which govern vision are adapted to the largest or smallest eye.

Musical sounds become known to us after they are thrown off from the vibrating instrument and enter our ears. But these sounds are for some little time retained in the different instruments, which vibrate so long as they thus remain, and always stop instantly as the sound leaves them. The vibrations are also diminished in exact proportion as the sound is drawn off.

That this sound thus originating in shock, and finished by the action of the body in which it is made, is the cause of continued vibration, is proven by the fact that when it enters another body, having the same normal vibration, it immediately sets this second body in vibration, which will continue for a while after the vibration in the first body stops. It follows that if the sound in the first fork causes the second one to vibrate when it enters it, it must have made the first, a precisely similar fork, or body, vibrate when it was in it.

In this last case there has been no additional shock, and therefore the acting sound must have been aroused by the original shock, and through a conductor transferred to the body of similar character to the one in which it was made, and therefore causes it to vibrate, as it did the first, and in the same manner throw off the sound which was not thrown off in the original sounding-body, but instead conducted here.

We have called attention to the fact that artificial mills or mills made by man, as lumber, woolen, cotton, silk, etc., do not make the material of which their goods are made, but simply manufacture the different varieties of goods; and we have shown that the fundamental principle of Sound is motion, which remains the same for the same medium whatever may be the intensity or other characteristics of Sound. We have also referred to instances where the material manufactured helps produce the force which manufactures, which is the condition here.

The text-books tell us that the length of the sonorous air-waves, which they call Sound, varies from 72 feet to a minimum, and that the waves by a woman's voice average in length from

2 to 4 feet, and by a man's from 10 to 12 feet. In wood or metal, sound going much faster than in air, these are supposed to be over 1100 feet long, and all of them, as the text-books teach, represent the correlative of Sound, and must be delivered to the ear in perfect condition. It will readily be seen that in ordinary conversation, at least in much of it, there is no such amount of room at command. All of this conversation might be spoken directly into the ear and heard perfectly. And thus, the absurdity and impossibility of the theory is again manifested.

The Rev. James Challis, for many years Professor of Astronomy at Oxford University, England, says:

> "The possibility of hearing distinctly words spoken at a distance, depends on the faithfulness with which the air transmits the impressions made on it by the organ of voice. As the difference between the sound of one letter and that of another corresponds to a difference in the form of the curve representing the succession and magnitude of the condensations impressed, it is necessary that the form should remain unchanged by distance of transmission in order that words heard at different distances may be the sounds."

We have shown that the general arrangement of the auditory nerves is not unlike that of the olfactory nerves, the last of which are admitted by all to deliver infinitesimal particles of matter to the nostrils.

We have shown at length that Sound, conversation or otherwise, will always get into a wire, if given any opportunity, and travel in it whilst it lives, without any electric current, and can be plainly heard with telephone arrangements for quite long distances. We have shown that to the speed of Sound in air is added the speed of the wind. And thus to the speed of Sound in a wire is added the speed of the electric current.

From experiments, acknowledged by all scientific writers to be correct, it is proven that the intensity of Sound depends upon the density of the air where it is made. And this means, and can mean nothing else than that Sound is manufactured from materials a part of which at least exist in air. This alone demonstrates the corpuscular theory of Sound true, and no scientist, or text-book, denies the evidence.

And it is no more true that unless the oak was a substantial thing it could not make the acorn that would reproduce it, than that if Sound was not a substantial thing it could not make an instrument that would repeat it.

And this again is a complete demonstration that the corpuscular theory is true.

In discussing the ear-trumpet, speaking-trumpet, and megaphone, it is perfectly evident that they are made to collect particles of Sound, and conduct them to the ear, as a hopper conducts grain. We have shown that the various explanations, absurd upon their face, of these instruments, made by scientists, have all been proven untrue and given up. The ear, too, is formed on the same general principle, to catch solid substantial particles of matter, passing through the air in large quantities; but of what possible use could it be with impossible air pulses varying in length from a few inches more or less to above 1100 feet? It might far easier collect soap bubbles.

The whole theory is the quintessence of nonsense invented at a time, thousands of years ago, by those who held that the world was sustained by a pillar, and the pillar rested upon a tortoise's back; and retained now simply and wholly for commercial purposes.

Of course only a small part of teachers teach physics, and, of those who do, we do not suppose that the great majority have ever fully realized their falsity, but at the bottom the force that is carrying these ridiculous errors is commercial; because there is money in them. It is certainly full time that such monstrous blunders were corrected.

We can see now from the action of the wireless telegraph, made so prominent in the recent destruction of the steamer Republic, that electricity radiates from a centre very similarly to Sound. Nor is its action any more remarkable. In both cases it is infinitesimal particles of matter moving from a centre, the electricity infinitely the fastest, although Sound is composed in part of it.

In the direction of the new physics we have shown that motion is unquestionably one of the many principles of matter, each created to perform some particular function, matter being composed of these principles as an aggregate, and motion that one of them, perhaps the most important of the whole, which makes matter move.

And we have shown that Sound is matter in motion, formed by shock, its particular character decided by the body in which it is made, when it is thrown off into the air by the vibration of this body, and thus distributed in every direction so as to perform its mission.

We cannot find a definition in any text-book of a normal vibration, but we assume that the normal vibration of every body is such as it makes when struck, if not interfered with; and this is always the same in the same body, and generally different in different bodies, but sometimes the same, when they are said to vibrate in unison.

After repeated experiments with forks of the same vibration, our experience is, that if one fork is struck and the other is then brought in close contact by touch (as placing together the ends of the stems), the second fork will begin to vibrate synchronously, and continue to for a little time after being separated, emitting the same sound as the first.

We have not been able to get such result by placing two forks of different vibration near each other, although a second fork thus placed of different vibration will act when connected as a conductor,—the same as a wooden scantling, telegraph wire, or any other conductor,—of the sound made by the first fork. In this case the sound stops immediately with that in the first fork which is furnishing the supply.

All hard bodies, or so-called elastic bodies, emit a sound when struck, and this is always the same for the same body, if similarly struck, but varies in intensity with the blow, and somewhat by the manner or thing with which it is struck. Strike a book lying flat on the table, it gives one sound; strike it standing on one edge, it gives a different sound.

The principal difference in sounds comes first from their length of duration; second from their pitch or tone; third from their intensity; and fourth from their quality. The first depends in part upon the blow or shock which starts them, and indirectly upon the usual infinite number of preceding causes.

The second depends upon the amount of a particular kind of Sound which comes to the mind in a certain definite time.

And therefore the universal principle in nature that effects are proportional to amounts decides the tone.

The third is directly decided by the strength of the shock, or disturbance; second by the density of the air in which the sound is made. (We haven't proven this ourselves, but suppose it to be true, because so stated by a number of able experimenters, and also in every important book of Physics, or Encyclopædic article on Sound, which we have seen; but it is always given without comment.) So far as we know there is but one possible explanation, that Sound is composed in part, and a very important part if not entirely, of material contained in air. The fact that Sound is said to be more intense in water than in air would sustain this suggestion, as pure water is composed of two parts of oxygen to one of hydrogen. The intensity is also in accordance with the universal principle in nature that effects are proportionate to amounts.

In the article that we have quoted from the French scientist, Ferdinand Papillon it is proven that in the kindred sensation of smell, odors made in air similarly to Sound, and wafted into the nostrils, are almost entirely composed of carbon and hydrogen, with or without oxygen.

Sound being electrical exerts power in the same manner as the lightning, only in infinitesimal quantities, and by this power makes the graphophone record.

The remarkable thing in this is that every sound (unless two sounds made by the same or a similar body) acts with different force, and so produces an entirely different instrument. So that this wonderful thing Sound, in the aggregate, is able to make instruments which will repeat all the sounds of the world, but each instrument can repeat only one sound. And this further is remarkable in the graphophone record; it is composed of a very large number of indentures and by experiment it will be found that it takes 75 or 100 of these, more or less, to repeat a single word, or letter, which shows that Sound is uttered with great rapidity, and that its utterance includes any amount of shading, what is technically called *color* or *timbre*.

Every instrument must be played on to repeat any sounds, which, as we have said, enforces the absolute necessity of shock for the production of Sound.

Over 200 years ago, Thomas Hooke, a contemporary of Newton, in demonstrating memory to be a record, was asked how he accounted for the memory of sounds.

His answer was "There is a little instrument here (pointing to the brain) that repeats them. And,"—he added—"it might be made artificially."

We have shown that the usual comparison of so-called sound waves with water waves is a humbug, not the slightest resemblance being possible between them.

The water waves are on a surface; the assumed sound waves in the body of a fluid. The water waves are the result of gravitation and momentum, neither of which could influence these hypothetical sound waves. The water waves move at the slow rate of about seven feet a second; the supposed air pulses at about eleven hundred. The water waves are substantial; the sonorous ones, wholly mythical.

On strictly scientific principles we have proven this undulatory theory of sound to be erroneous; on far broader principles, those which have to do with the construction of creation, we have shown all undulatory theories to be incorrect, for there is nothing done that way. The principles governing the universe, certainly in these regards, are plainly enough manifested and of very different character. Not only the laws which control matter, but those which connect with the interaction of mind upon matter, or matter upon mind. Indeed the whole system of the universe is as different from the teachings of science in these and many other respects as the East is from the West. The one is magnificent and true; the other cramped, and inconceivably absurd as well as false. The average teacher in such subjects is entirely unable to withstand the assertion of authority from those who have been promoted,—blind leaders of the blind. But there are signs now throughout the scientific world of a reaction; the dawn of a brighter morning for science, when the New Physics will everywhere prevail, and we will hope not only the substantial and uniform laws which exist in the material universe be perceived, but far above these, those that govern spiritual existence, that as yet we have but a very indifferent knowledge of.

Indeed, there is no organ by which man can see this at all, but it is the power that creates all things; the power which continues their performance; the power which thinks; the power which loves; the power that is in touch with all existence; before which the speed of electricity, or light, pales into insignificance. For whilst, as the philosophers tell us, and we know no reason to doubt it, there are innumerable stars whose light has not yet had time to reach this earth although moving at the rate of 184,000 miles per second, by thought we can instantly span such distance, and thus come in touch with all. Nor is it possible to say that this thinking part of ourselves, at any moment, when it passes from one phase of existence into another, may not awake into the full glory of spiritual existence, equal in all its capacities to this instantaneous action of thought.

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APPENDIX

NEWEST THEORY OF LIGHT

WHICH MAKES IT A STREAM OF MINUTE BODIES

OLD IDEAS UPSET BY THE ARRHENIUS THEORY OF LIGHT PRESSURE—COMETS, THE ZODIACAL LIGHT AND OTHER PERPLEXING PROBLEMS EXPLAINED BY A SWEDISH PROFESSOR.

THE following is from a two-column article in the New York Sun of Sunday, August 30th. It suggests several very strong arguments in favor of the Newtonian or corpuscular theory of light; but even more suggests the strong hold the New Physics have already obtained among prominent scientists of different countries.

"Cambridge, Mass., Aug 29, 1908.—The theory of light pressure, the subject of discussion for some time past among astronomers, physicists and chemists, has begun to impinge itself upon popular consciousness.

* * * * * * * *

"But light, so well behaved, so definite and so positive in the laboratory, has been creating scandals among the makers of text-books. New sections have had to be added to explain the ultra violet microscope, and now the books apparently must be revised to include a theory which makes of the pressure of light a force co-equal in importance with gravitation.

"Just whether Arrhenius, Lebedeff, Hull and Nichols, whose names are associated with the recent discoveries of the cosmical significance of light pressure, have hit upon something as fundamental in the history of science as Newton's discovery of the law of gravitation, it would be out of place to attempt to argue now. Enough that their theories have proved to be immensely suggestive; that conservative astronomers like Prof. Edward C. Pickering at Harvard, whose work has lain in other than electro-chemical directions, are expressing themselves as intensely interested in the generalizations from the light pressure doctrine, and that to most people the conception of light as a propulsive agent is still new and even startling.

"That a beam of light theoretically ought to exert pressure upon whatever object it falls was evident in the days when the Newtonian theory of emission of luminous corpuscles was held by scientists. If a candle flame or a sun in burning threw off minute particles of material light, clearly the impact of these traveling at 186,000 miles a second should be considerable.

* * * * * * * *

"The Russian, Lebedeff, first proved experimentally that light exerts pressure. Prof. Nichols and Hull, working at Dartmouth College, confirmed his experiments and improved his methods.

"Meantime Svante Arrhenius of the University of Stockholm began drawing up statements of changes of cosmic theory that must take place now that a new factor in the frame work has been demonstrated. A few of the consequences of the acceptance of the light pressure theory as seen by this Swedish scientist may be set forth.

"The sunlight perpetually beating upon this planet exerts, according to the measurements of Arrhenius, a pressure of about 75,000 tons. That is a merely negligible force as compared with the pull of gravitation, many times as great.

"Out in the solar system, however; where there exists no one knows how tenuous a condition of the material filling in, the propulsive force exerted by the light upon any little particle of matter that is flying about may be quite as potent as the power of gravitation that tends to draw all things together. Light pressure, in other words, appears to be a foil to the universal get together tendency.

"Just why this force is relatively more important when acting upon minute than upon large masses will be evident on a moment's consideration. Gravitation acts upon masses as a whole. Light pressure is exerted only on surfaces.

* * * * * * * *

"And now comes the Arrhenius theory to interpret in terms of the light pressure discovery a list of perplexing problems, such as the aurora borealis, the zodiacal light, the turning of the comet's tail away from the sun, the drainage of the silicious matter composing Saturn's rings and the glow of distant nebulæ.

"Discussion of light pressure is inextricably bound up, of course with the doctrine of the sun's bombardment of space with corpuscles negatively charged. According to the theory these off-shoots from every luminous body in the universe colide in the intersolar spaces and there form the matter that, hurried now hither now hence, under impact of the forces of gravitation and light pressure may make up the lonely wandering meteors or the myriad swarms that constitute the comets.

"There exists, in other words, in Arrhenius' thought a complete circulation of matter in the universe. The meteoric dust falling today through our atmosphere is a compound projected not from our sun alone but from many other suns many light years ago. A portion at least of the soil beneath our feet has come recently, as cosmic processes are measured, from outside our own solar system.

"In terms of these universal showers of negatively electrified particles the glow of the cold masses of gas known as nebulæ is explicable. Matter in embryo shot at high speed into the nebulæ flares up precisely as the meteors catch fire on encountering our atmosphere. After centuries, millenniums, the glimmer reaches this earth. The hypothesis explains the brighter glow of the outer parts of these gaseous masses, the interiors, untouched by the rain particles, lying in coldness.

"That such of the accretions from electrified corpuscles as are gathered in cometary form are perpetually subject to the conflicting forces of gravitation and light pressure, is visibly demonstrated whenever a comet approaches the sun with its tail, full of hydrocarbons, turned outward. This phenomenon, which has long perplexed the wise, is just what would appear if, as the wanderer approaches the sun, the coarser grains of solid matter are large enough to resist the light pressure while the smaller particles are knocked galley-west by the sunlight sometimes forming several distinct tails.

"The theory offers an easy explanation of the corona of the sun itself, the beautiful floating clouds seen at the time of an eclipse, which in the absence of a celestial atmosphere have heretofore passed the wisdom of the astrophysicist to interpret. How can material clouds float in no medium but impalpable and unbuoyant ether?

"Arrhenius maintains that the inflamed corpuscles thrown off from the fiery mass of the sun are of various sizes and that the distances to which they are projected depend entirely on their diameters. Those which are so large that the attraction of gravitation exceeds the propulsive power of light naturally drop back into the glowing chromosphere. A limited number have precisely the critical diameter. That is to say, their size is such that the two opposing forces neutralize each other and the particles, suspended at a considerable height, drift around the sun in the form of the clouds that are visible to the human eye on a few occasions in each century. The total weight of the corona is not considerable; it has been estimated at about 12,000,000 long tons, which hardly exceeds the amount of coal burned on the earth in a week.

"Those particles that have less than the critical diameter are of course sent scudding to the utmost bounds of the solar system and beyond.

"Unless, that is, they happen to hit one of the planets in transit. Some of them reaching the atmosphere of this earth produce the phenomenon of the aurora borealis—a celestial analogue of the stream of light produced in a Crookes tube when electricity is flashed through it, and easily influenced, as every class in physics has noted, by the presence of a magnet."

WORKS OF JOSEPH BATTELL,
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PREFACE TO THIRD EDITION OF VOLUME I.

VOLUME II. of "Ellen or Whisperings of An Old Pine," has cleared the way for the acceptance of the corpuscular theory of sound, and of necessity the reëstablishment of the corpuscular theory of light, as expounded by Newton. The wonder is that Newton's discoveries in regard to light, shouldn't have corrected the erroneous theory of sound, that for thousands of years, in some of its phases, has been allowed to continue, unsupported by a single gleam of common sense, without which all pretended expositions of science are worse than worthless.

When "Ellen" was undertaken it was hoped that, following the Platonic system of dialogue, which is especially fitted for the discovery of truth, it would be possible to solve all the different and more difficult questions that connect with the nature of existence, either material or spiritual.

It is first shown in "Ellen," that the only law of material creation is the combination of matter in its different conditions and proportions. This law is sufficient for the construction of every material thing in the universe, including all the infinite changes constantly and continuously taking place. A million laws couldn't do any more than this can. Nor could a million minor laws convey more clearly to the mind the universal character of material existence, whatever be the essence of matter, or however it is created. This law is of course conclusive of the nature of Sound.

Mathematics are comparatively easy, readily yielding to common sense methods, so that the consideration of these became soon a pastime; the unnecessary mistakes which had been allowed to creep into and befog them were readily got rid of and the perverted uses, which they were being constantly called upon to perform, pointed out.

There remained the enigma of life with all its hopes for the future, universal among mankind, and yet obscured with many a doubt. Good sense tells us that these hopes or beliefs would not exist if they were not true. But all would like to know how they are accomplished. This we believe is explained in "Ellen." Briefly stated it is that God not only made matter, so that, with the laws controlling it, it will accomplish the creation of every material thing, and that with the greatest ease and perfection; but also created, or supplied, another substance, mind, entirely distinct from matter, to be used in connection with it, and equally essential to the creation.

It holds to reason that the Power which made one of these could make both. With the two substances, each very remarkable, although the last by far the most so, an infinite universe of infinite variety and infinite beauty is possible. Without both no such universe could exist.

The mistaken idea that matter only is necessary for the construction of the universe, is mainly if not entirely responsible for the large amount of ignorance which prevails in regard to our present existence, and still more in regard to continued existence. Supposing mind and matter are both distinct substances, especially provided, for such purpose, the question at once becomes simple.

For it is readily seen from known facts how such an existence can be, and apparently is continued. And these facts include or suggest every requisite necessary to an existence capable of continued improvement, until it may reach that state, which Paul refers to as spiritual.

That is, the body, every body, being only a machine for the use of the soul, any soul, the destruction of it, in the nature of things, does not and cannot affect the essential existence of the soul. It takes from it certain possessions which through the aid of the body it has accumulated. But the loss of possessions is something which every soul constantly experiences, and, in this case, it is a loss of those which can be of no further use. Machinery adapted to the change of existence, with which to accumulate new possessions, is undoubtedly again supplied, and thus the soul continues its existence and may indefinitely continue it, or it may at any time, so far as we know, rise to a higher existence, which changes not.*

These conditions are so vividly portrayed by St. Paul in I. Corinthians, Chap. 15, that we quote several verses:

"Awake to righteousness, and sin not; for some have not the knowledge of God: I speak *this* to your shame.

"But some *man* will say, How are the dead raised up? and with what body do they come?

"*Thou* fool, that which thou sowest is not quickened, except it die:

"And that which thou sowest, thou sowest not that body that shall be, but bare grain, it may chance of wheat, or of some other *grain*:

"But God giveth it a body as it hath pleased him, and to every seed *its* own body.

"All flesh *is* not the same flesh: but *there is* one *kind of flesh* of men, another flesh of beasts, another of fishes, *and* another of birds.

"*There are* also celestial bodies, and bodies terrestrial; but the glory of the celestial *is* one, and the *glory* of the terrestrial *is* another.

"*There is* one glory of the sun, and another glory of the moon, and another glory of the stars: for *one* star differeth from *another* star in glory.

"So also *is* the resurrection of the dead. It is sown in corruption, it is raised in incorruption:

"It is sown in dishonour, it is raised in glory: it is sown in weakness, it is raised in power:

"It is sown a natural body, it is raised a spiritual body. There is a natural body, and there is a spiritual body."

It will be noticed that in these verses the word "body" occurs ten times, and it is very evident that St. Paul perceived, or believed, that a body, some kind of a body,—which would mean one adapted to the sphere in which the soul dwelt, it might be terrestrial, celestial or spiritual,—was a necessary adjunct to a soul in many if not all conditions of its existence.

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* See Heredity, pages 179–184; also Nature of the Soul, 275–286.

The necessities of a diver in the water, for additional machinery to supply air and for other purposes, illustrates the necessity of the soul having a body adapted to the elements in which it may exist.

We have had occasion several times in "Ellen" to criticise a too great dependence upon the system of experimental, or Baconian, philosophy. Experiments are excellent to furnish data for the reasoning powers; but intelligence alone perceives anything, nor is it possible with the physical eye to get any knowledge of the essence of things. With the mind's eye only can we hope to do this. And therefore the theories of science, so far as based upon scientific experiment, are to a very large extent, and always will be, entirely erroneous.

But whilst experimental science is thus limited in its researches, the facts it obtains are the material from which this edifice of knowledge must be built. And as in all construction of material things it is the workmen,—the day laborers,—who gather the material, but the architect who designs the building, so it is here. Science provides the material, but Philosophy must build the structure.

Plato had occasion to enforce this principle of the superiority of mental over physical vision [see page 147 of this volume].

In a more homely manner Mr. Huxley refers to the same subject, as follows:

> "No delusion is greater than the notion that method and industry can make up for lack of mother wit, either in science or in practical life; and it is strange that, with his knowledge of mankind, Bacon should have dreamed that he, or any other, 'via invendiendi scientias' would level men's wits and leave little scope for that inborn capacity which is called genius."

The eminent French scientist, Ferdinand Papillon, says:*

> "Descartes, Leibnitz, and all the great minds of the seventeenth century, believed that phenomena are such interdependent parts of one whole, that they require to be explained by each other, and consequently, that a very close mutual connection should be maintained among the sciences. In their view, this was the condition of rapid advance and intelligent development. The experimental method, constant to systematic obstinacy in erecting so many barriers between the different sections of natural philosophy, has greatly hindered the completeness of whatever knowledge we possess as the result of mutual interaction among all truths. At this day, such barriers are tending to vanish of their own accord, and the science of man in his relations with external media begins to show the outlines of its plan and harmony."

And more recently Mr. Balfour, President of the British Association of Scientists, closes his address at their annual meeting with the following eloquent period:

> "Considerations like these, unless I have compressed them beyond the limits of intelligibility, do undoubtedly suggest a certain inevitable incoherence in any general scheme of thought which is built out of

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* See "Ellen," Vol. II., Part II., page 14.

materials provided by natural science alone. Extend the boundaries of knowledge as you may; draw how you will the picture of the universe; reduce its infinite variety to the modes of a single space-filling ether; retrace its history to the birth of existing atoms; show how under the pressure of gravitation they become concentrated into nebulae, into suns, and all the host of heaven; how, at least in one small planet, they combined to form organic compounds; how organic compounds became living things; how living things, developing along many different lines, gave birth at last to one superior race; how from this race arose, after many ages, a learned handful, who looked round on the world which thus blindly brought them into being, and judged it, and knew it for what it was: perform, I say, all this, and though you may indeed have attained to science, in nowise will you have attained to a self-sufficing system of beliefs. One thing will at least remain, of which this long-drawn sequence of causes and effects gives no satisfying explanation; and that is knowledge itself. Natural science must ever regard knowledge as the product of irrational conditions, for in the last resort it knows no others. It must always regard knowledge as rational, or else science itself disappears. In addition, therefore, to the difficulty of extracting from experience beliefs which experience contradicts, we are confronted with the difficulty of harmonizing the pedigree of our beliefs with their title to authority. The more successful we are in explaining their origin, the more doubt we cast on their validity. The more imposing seems the scheme of what we know, the more difficult it is to discover by what ultimate criteria we claim to know it.

"Here, however, we touch the frontier beyond which physical science possesses no jurisdiction. If the obscure and difficult region which lies beyond is to be surveyed and made accessible, philosophy, not science, must undertake the task. It is no business of this Society. We meet here to promote the cause of knowledge in one of its great divisions; we shall not help it by confusing the limits which usefully separate one division from another. It may perhaps be thought that I have disregarded my own precept—that I have wilfully overstepped the ample bounds within which the searchers into Nature carry on their labours. If it be so, I can only beg your forgiveness. My first desire has been to rouse in those who, like myself, are no specialists in physics, the same absorbing interest which I feel in what is surely the most far-reaching speculation about the physical universe which has ever claimed experimental support; and if in so doing I have been tempted to hint my own personal opinion that as natural science grows it leans more, not less, upon an idealistic interpretation of the universe, even those who least agree may perhaps be prepared to pardon."

It is very evident that this President of one of the most prominent associations of scientists in the world is perfectly conscious that science, in its own workings, is utterly incapable of perceiving the ultimate cause of things, without which there can be no satisfactory knowledge. The best it can do, as before suggested, is to obtain certain sense perceptions, which can extend only to the things experimented with, but not at all to their hidden causes. These can only be reached by the reasoning powers, which are the tools of philosophy, and therefore, as Mr. Balfour says, "Philosophy, and not science, must undertake the task."

We have seen nothing that throws so much light upon the incredible amount of nonsense that is being, or has been taught by the ignorance of science as this letter of Mr. Balfour. The extreme folly of the rational coming from the irrational is very evident to every intelligent reader. Mr. Balfour, of course, perceives it, and therefore adds the next most remarkable sentences though still striving to pose as a scientist. And then in the closing paragraphs he interprets what before he had but suggested, and without further words lets science down into her natural place, and boldly proclaims the superiority of philosophy.

But Philosophy, so far as it is of any value, is a power of right perception. By definition the philosopher is a lover of wisdom and therefore a believer in Truth and a follower of Right.

In connection with Mr. Balfour, who most eloquently has expounded a true philosophy, we will let speak the most renowned of all philosophers, whose fearless love of Right and Truth earned for him the title of divine. In the Phaedo, Plato says:

> "Then I heard some one who had a book of Anaxagoras, as he said, out of which he read that mind was the disposer and cause of all, and I was quite delighted at the notion of this, which appeared admirable, and I said to myself: If mind is the disposer, mind will dispose all for the best; and I argued that if any one desired to find out the cause of generation or destruction of existence of anything, he must find out what state of being or suffering or doing was best for that thing, and therefore a man had only to consider the best for himself and others, and then he would also know the worse, for that the same science comprised both. And I rejoiced to think that I had found in Anaxagoras a teacher of the causes of existence such as I desired, and I imagined that he would tell me first whether the earth is flat or round: and then he would further explain the cause and necessity of this, and would teach me the nature of the best and show that this was best; and if he said that the earth was in the centre, he would explain that this position was the best and I should be satisfied if this was shown to me, and not want any other sort of cause. And I thought that I would then go on and

ask him about the sun and the moon and stars, and that he would explain to me their comparative swiftness, and their returnings and various states, and how their several affections, active and passive, were all for the best. For I could not but imagine that when he spoke of mind and explained to me in detail the cause of each and the cause of all, he would go on to explain to me what was best for each and what was best for all. I had hopes which I would not have sold for much, and I seized the books and read them as fast as I could in my eagerness to know the better and the worse.

"What hopes I had formed, and how grievously was I disappointed. As I proceeded, I found my philosopher altogether forsaking mind or any other principle of order, but having recourse to air, and ether, and water, and other eccentricities. * * * But to say that this is the way in which mind acts, and not from the choice of the best, is a very careless and idle mode of speaking. I wonder that they cannot distinguish the cause from the condition, which the many, feeling about in the dark, are always mistaking and misnaming. And thus one man makes a vortex all round and steadies the earth by the heaven; another gives the air as a support to the earth, which is a sort of broad trough. Any power which in disposing them as they are disposes them for the best never enters into their minds, nor do they imagine that there is any superhuman strength in that; they rather expect to find another Atlas of the world who is stronger and more everlasting and more containing than the Good is, and are clearly of opinion that the obligatory and containing power of the Good is as nothing; and yet this is the principle which I would fain learn if any one would teach me."

PREFACE TO VOL. II.

IN presenting to the public Volume II. of "Ellen, or Whisperings of an Old Pine," the author would say that while there have been quite a number of favorable notices of Volume I., and suggestions that its reasoning is correct, no attempt has been made anywhere to answer its criticisms of modern science, although the Rutland Herald, one of the largest and ablest of Vermont daily papers, says editorily that "'Ellen' is a series of Platonic dialogues designed to make an all-around attack upon science as it is taught in the schools. Before its quick-firing batteries evolution, the undulatory theories of matter, certain propositions in algebra and geometry, the nature of the soul, and other philosophic and scientific tenets, long considered secure, are razed to the ground." And adds: "As two more volumes are promised, we will not here record our impression of the Battellian theory of creation; but we will say that in just this way the thoughts of man have been turned from the ruts of error into truth."

And yet there was no intention, much less desire, in writing "Ellen," to attack anything or anybody.

After finding that modern science, in certain things, certainly, was badly in error, an earnest attempt was made, on common sense lines, to arrive at the truth of the difficult subjects considered.

It at once became evident that the Universality of Natural Law, upon which all science rests, was the key with which to unlock the secrets of nature. For whilst we can have only opinions, which, as Socrates said, "are bad, all," of how things are accomplished which are beyond out perceptions, we know how *we* do them, or how they are done by any order of mind whose methods come within our observation.

But we find that all things made by man,—who has a large amount of constructive ability,—are made from matter, to conform to a model in mind. That is, every material thing is a copy, the things it is copied from being a spiritual or mental production; and therefore the whole conception of evolution by material forces is a palpable humbug.

Again, we find that man in creating things works by special creation. That is, if he wants a piano he does not make a violin, or any other material thing, which will evolute into a piano, but directly, through the operations of mind, he makes a piano; and this method is universal with him, and with any other order of mind with which we have acquaintance. And thus again material evolution is proven to be a humbug.

The evolution takes place, in the line of improvement and variety, but it is accomplished by mind not matter. Thus an ordinary railroad car evolutes, in the mind, to a palace car, and afterwards by the direction of mind the material for this palace car is gathered and the car built; but the ordinary railroad car from which it was designed is still running, not a single particle of its material entering into the improved car. Similarly in nature are made the different varieties and species of things.

"Ellen" also demonstrates that the body is a machine; not only the material part of the body which we see, and which remains a limited time after death; but as well that which we call the life of the body, the respiration, circulation of the blood, digestion and assimilation.

Then must the intelligence that runs it be entirely independent of it. Of this there can be no question. For the laws of nature are universal; and when the intelligence which operates any material thing is found in one case to be entirely distinct from that thing, we know that it is so in all cases, whether or not our physical vision is able to detect it. But that they are thus separate we know to be true in regard to an engine, and all machinery made by man, and therefore is it true throughout the universe.

The entirely material character of the body may be seen in the nature of its forces, and the various devices used in the different parts of the machinery, such as joints, valves, hinges, etc., which are precisely similar to those used for similar purposes by man; also, in the fact that we can see the operations which take place, as completely as we can those of a clock or factory. In either case intelligence must be at hand to guide the running, but in either case a certain part is entirely mechanical. It is further demonstrated by the fact that it is impossible for the will directly to stop the beating of the heart, or permanently the act of breathing.

For a body, as for an engine, supplies of fuel are needed. But all the designs of intelligence are for the use of intelligence. There is no other cause or occasion. And, too, every design of intelligence must be looked after and operated by intelligence.

And therefore it is just as necessary that this machine of the body should have an engineer,—that is, intelligence to look after and manage it,—as that an engine should. In this case there is no difference in the order of intelligence which operates, only in one case it is called an engineer and in the other a soul. They are one and the same thing. That is, the soul clothed with the apparel of the body, which is necessary to its action in material conditions, becomes the engineer.

This same soul has to supply both the machinery of the body with fuel, and the engine that it runs. It is dependent upon the engine for its ability to travel quickly or to draw freight; and it is dependent upon the body to live among and operate material things. The two conditions are similar, and the one not in any way more remarkable than the other. Both take place in accordance with the laws governing the construction of the universe. Nor is it possible to conceive how a universe, or any part of it, could exist without design, or laws to govern it, nor how any better could be made than those which operate. But they are all of a practical character and of universal application.

It follows that a soul must enter a body in connection with, or soon after its organization, and this in as distinct a manner as an engineer enters an engine.

Bodies are produced through the processes of generation, and are made for the use of the soul whilst living or in material conditions as much so as an engine or any vehicle is for the use of man.

The soul dwells in a body, and uses the facilities of the body for its convenience. And so, too, in connection with the body, it enters a house, a boat, a car, a carriage, a balloon, or indeed any material thing, which it is able to use for its convenience or pleasure.

It would appear that it uses bodies in material conditions as, in connection with the body, it uses boats to travel upon the water, and in each case for the same reason, because it cannot live in material conditions, or travel upon the water to advantage, or for any long time, without such aid.

These contrivances of the body are, then, but some of the innumerable material things which souls use in the various phases of their existence. For souls are as numerous throughout the universe as trees in a forest, and as active as fishes in a sea. They unquestionably constitute a very important part of the universe, acting under the authority of a Supreme Ruler, and in accordance with laws made by Him. Like all things, they are individual, and the nature of their existence is occupation or action. That is what existence means.

The innate power of the soul is also demonstrated in "Ellen," which shows that Locke's contention that there is no such thing as innate ideas, if interpreted to mean that there is no such thing as a soul, was not correct, as it would be as utterly impossible for concepts to arrange themselves into thought, as for numbers or letters upon a blackboard to do so, or for a bottle of ink to write a novel. There must be something back of the concepts to do this, This something is the soul.

And though it would appear to have no ideas of material things, until they are brought within its comprehension, its power to learn is innate; and also its power to construct and use. Then must its knowledge be innate, for it is impossible to conceive how a soul can construct or use anything without knowledge. But innate knowledge means knowledge that has existed perhaps from eternity, and perhaps that will exist to eternity. That is the soul is an immortal substance, having the power of thought and feeling.

All of the conditions which lead up to this demonstration are carefully explained in the first volume of "Ellen." The present volume is almost entirely occupied in the discussion of the last eight books of Geometry,—that of the first book appearing in Volume I.,—Plane Trigonometry, and the Undulatory Theories, especially that of Sound. This last was considered, in part, in Volume I. of the first edition of "Ellen," but has been carefully revised, and the action of sound in the telephone and graphophone, a very important feature, added. It is very evident that all the explanations of modern text-books, as based upon the undulatory theories, are incorrect. That such a theory ever took root is most extraordinary, as there isn't a single one of its essential features that comes within the scope of possibility.

The statement upon which it starts, that sound is made by vibrations hitting particles of air, or other particles, so as to produce so-called sonorous waves, is without any possible basis, as can be proven by five minutes' experiment with a tuning fork. Sound exists first in the fork, or any vibrating body, before it enters the air. It is produced by shock—a blow—and, as is proven in this volume of "Ellen," consists of infinitesimal particles of electrical matter, which, like the light-footed Aurora that in a moment may span the whole arch of heaven, returning in another to its northern palaces, have the power of movement; and although with sound this movement is not especially rapid it is adapted like all of nature's works, to the purposes for which it is made, and rapid enough, and far extending enough, to accomplish these both thoroughly and agreeably.

Because of its infinitesimal character sound is able to pervade every part of the atmosphere, and thus to enter all ears; and also because of this, different sounds can pass each other, continually and without serious difficulty, as people can, or flies. There is no other way for things to pass, no other possible way. Motions under certain conditions will go from one body to another, when these bodies touch, and, being forces, carry the bodies in which they remain. Sounds pass each other because there's room for them to. The example of a supposedly different method,—that of water waves,—is a delusion, as is fully explained in this volume, and as should have been perfectly known and explained by all text-books or teachers of sound. The waves do what the boat does that rides upon them, go up and then back, whilst with each excursion a new circle of waves is made through the joint action of momentum and gravity.

The statement that the slow movement of a tuning fork—not over about seven feet a second—or any other similarly vibrating body, causes particles of air, or anything else, by hitting them to move 1040 feet, more or less, a second,—upon which the undulatory theory of sound rests,—is a monstrous lie, as any person with any knowledge of the laws of mechanics knows.

The sound, after being formed in the vibrating body by the shock, is easily and certainly traced in its onward mission. Vibration moulds it, and throws it into the air whence it is most easily distributed in all directions, although it can be carried in greater quantities and far more quickly by a rod of wood or metal, letting the lower part of the fork touch one end of the rod, the other end being held in the teeth or placed against the bones of the chest or head.

Indeed, it was the perception of the inconsistency and absurdity of these undulatory theories more than any other one thing, which first influenced us to criticise modern science. It was too plain a case to be ignored. The absurd statements in the text-books in regard to the nature of matter and motion were equally prominent, and soon it was evident that the scientists had made a bad mess of it generally, one error leading of necessity to others, until the whole structure of modern science is perforated with them.

Part II. of this volume, which treats of the undulatory theories, was written in part before the discovery of radium, by which now, as also by X and Cathode rays, Newton's corpuscular theory of light is demonstrated experimentally to be correct, and all undulatory theories erroneous.

For any suggestion that nature has two methods of producing light cannot for a moment be entertained; nor could it possibly be suggested by any one who, as Newton expresses it, has in philosophical matters a competent faculty of thinking.

In the appendix of this volume and Preface of Volume I., second and third editions, will be found references to several articles from very prominent physicists, admitting a change of opinion in regard to these theories; and indeed we know of no eminent physicist, and doubt whether there is any, eminent or not eminent, certainly no intelligent one, who would now undertake openly to sustain them.

And yet the anomalous condition exists, so far as we know both in this country and Europe, that they are still taught in every college and scientific school. Whether in teaching them the scholars are told additionally that they are utterly erroneous we do not know, but doubtless most of them have found out that they are so.

The new lines of demonstration chosen in geometry, which appear for the first time in this volume, practically revolutionize the science, making it much simpler and plainer.

The object of a book like "Ellen" is the finding of Truth, the nature of this endeavor being double, to correct what is erroneous, and to discover new truth. Certainly in the first the book has been very successful. Starting out single handed and looking upon the subject simply from a common sense standpoint, it demonstrated the absurdity and impossibility of a large part of the physics as taught in all text-books. It also demonstrated the impossibility and absurdity of the Darwinian theory, or any theory of material evolution. It also detected many errors in other branches of philosophy and science and exposed some very blundering and entirely erroneous statements in mathematics, all of which errors have been hitherto accepted in all modern text-books, and some for hundreds of years. No answer has been made to any of these criticisms, as indeed none is possible, but the more distinguished scientists of the world have already accepted the more important positions taken in "Ellen," which took the lead, and whose ideas were widely advertised in the newspapers and in the circulation of the books when the first edition was published, in 1901. And this means that a large part of the science of the world, as taught in the text-books and sustained in encyclopædias, is being slowly but surely revolutionized.

In this department alone the necessity of such a book as "Ellen" has been fully vindicated. In the second field, that of independent discovery, "Ellen" has been, perhaps, equally successful, and the numerous discoveries made in the nature of existence, and the order of the universe, promise to lead to others even more important.

It is not true that such a book is or can be dry or uninteresting. Many of the truths which it seeks are the most important and intensely interesting of all; for they have to do not only with the affairs of this life, but with its destiny, the life which we believe to be succeeding this, as surely as day succeeds the night, or night, day.

For some years a wave of materialism has swept over the world, permeating all society with its baneful influence. And this, although nothing can be more certain than that the soul is a substance, entirely distinct from the body, and must continue to exist with all its original powers, when, the life of the body being spent, it is no longer habitable for a soul.

And from the opposite, death, is the beginning of a new life —the dawn of another day. For the day comes from the night and the night from the day. They follow each other in succession, nor is it possible that they would do otherwise, the great system of order, in which or by which the universe is constructed, forbidding it.

And so life comes from death and death from life; according to the great law of opposites, universal in nature.

And that which follows is controlled by another of nature's universal laws, that of cause and effect. As Paul expressed it "Be not deceived, God is not mocked. For whatsoever a man soweth, that shall he also reap."

All of this is plain common sense; the fundamental truths of existence; the fundamental truths of religion; the fundamental truths of the Bible.

The next thing that the mind seeks is under what laws does existence continue. Is the spiritual always connected with the material—mind with matter, or any other substance, acting as a body? The only suggestion from analogy is that the soul when it leaves the body enters another body. Paul speaks of a spiritual body. Can the laws under which continued existence takes place be discovered by the mind of man? We believe that they may; that the spiritual part of man, the mind's eye, will fathom this mystery, so that the whole nature of that existence, of which we are a part, may become understood. But this will depend upon the highest possible motive—what is best.

There is indeed in "Ellen" but one more step to be reached, the first one being the perception that the soul is distinct from the body, and continues its existence. Christ's remark, "Seek and ye shall find," always true, points the way. And we know not why these laws will not become manifest, as others have in "Ellen" that seemed equally hidden; as the law of memory, the law of dreams, the nature of the connection of the soul with the body, the material character of truth, justice and all abstract qualities, the operation of light in vision, the nature of sound, the nature of matter, the nature of motion, and other most important truths, discovered first in "Ellen" or rediscovered, and presented so as to be accepted, the arguments sustaining them being too strong to be overthrown.

This book is dedicated to the American people because the great body of the people is the ultimate authority for the decision of all questions which are world-wide in their scope.

Their attention may not ordinarily be called to questions looked upon as purely scientific, but when it is they are not hampered by "knowing so many things that are not so," as Artemus Ward said of the scientists, but will judge all questions upon their merits, and do it correctly.

JOSEPH BATTELL.

BREAD LOAF INN, RIPTON, VT.
October 1, 1907.

CRITICISMS AND REVIEWS.

James M. Ingalls, Lieutenant-Colonel, United States Army, one of the most eminent mathematicians in the world, and recognized as the highest authority on balistics, or the science of projectiles, writes:

MY DEAR MR. BATTELL:

I thank you very much for the copy of your great work "Ellen or Whisperings of an Old Pine," which I received a few days ago. Of course I have not had time to read the 800 closely printed pages, but I have looked it over very carefully, and I think I can say positively that it is the best argument against the present accepted theory of sound that has ever been presented to the public.

Sincerely yours,
JAMES M. INGALLS.

Prof. George F. Barker, of the University of Pennsylvania, one of the most eminent physicists of America, to whom we sent a copy of "Ellen," writes:

JOSEPH BATTELL ESQ.,

My Dear Sir:—I beg to express to you my thanks for the first volume of the second edition of your remarkable book, "Ellen". Obviously there has been much thought spent upon the reasoning contained in it and the criticisms it contains must, I think, tend to modify some of the views which are today held on these subjects. I shall be glad to see the second volume, since it proposes to discuss the theories of undulation which are more directly in my own line of study.

With kind regards believe me,

Very truly yours,

George F. Barker.

A number of other criticisms and notices have been received very favorable to "Ellen", noteworthy among them the fact that the Chicago Inter-Ocean, one of the leading journals of the West, gave a full page in its Sunday edition of May 12, 1904, to the book, prefacing with the remark that it was a curious and interesting book, and after the introduction of "Ellen" leads in many directions.

Of the second edition, but a few copies were sent to the press. In addition to the criticisms already quoted is the following review by Reed Moyer, editor, New Haven, Conn., which appeared in a syndicate of papers, including the Mobile, Ala., Times:

"A book that presents some rather interesting problems is entitled 'Ellen, or Whisperings of an Old Pine,' by Joseph Battell. The book is really a scientific discussion, but it takes the form of fiction, in which the chief characters are Ellen and an old Vermont Pine. A second edition has just been issued, and in the Preface to this edition, the author mentions with pride the fact that its revolutionary scientific theories have been accepted by leading scientists. Such questions as the nature of matter, and the phenomena of sound, light, heat and electricity are considered in a searching manner. In particular the book demonstrates the absurdity of the undulatory theories taught in every text book of physics. A great many mathematical statements, that are universally accepted, are exposed in such a way that the candid reader must confess that the author is correct. The book is not above the knowledge of the student of plane geometry and elementary physics. The questions discussed concern the basic principles of mathematics and science and cannot fail to be of interest to every educated person. The book is finely printed and bound and is published by the American Publishing Company, Middlebury, Vermont."

Mr. H. L. Hindley, editor of the Ludlow (Vt.) Tribune, and one of the abler reviewers of Vermont, after saying that the book is "iconoclasm, idol-breaking," continues:

"It won't do to dismiss Ellen and her conversations with an impatient shrug for the very simple and sufficient reason that there's abundant food for thought in them. There's a whole lot of rot about modern science, and the Colonel has certainly attacked it where its armor is a little thin—to say nothing about the sheathing underneath. It is impossible to even outline the arguments of the book—read it yourself if you have time."

Hon. H. H. Powers formerly a judge of the Supreme Court of Vermont, writes:

"Your work, 'Ellen,' is too profound for hasty judgment, but I have examined it far enough to discover that you have bestowed most careful thought upon your reasoning, and I think have evolved theories that stand on a logical basis, and are worthy the attention of our best scholars."

Hon. C. S. Emery, one of Vermont's most prominent citizens, and member of the State Senate, writes:

CHELSEA, VT., May 14, 1904.

HON. JOSEPH BATTELL,

My Dear Sir:—I am in receipt of the beautiful volume, "Ellen," from your pen, and shall always prize it on that account and must thank you for your thoughtfulness.

The amount of labor bestowed upon this work, the thought and study required in mastering the subjects treated, would seem to me to be enough for a lifetime.

Very sincerely yours,
C. S. EMERY.

Of the first edition Mr. Bryan in The Commoner says: "A very interesting book."

The Louisville Journal, edited by Henry M. Watterson, says: "A book with much ingenious construction of the most vital truths."

"Your argument against evolution is logical, and I believe unanswerable."—*Judge Rae of Chicago.*

Thomas H. McLeod, A. M., Middlebury, Vt., formerly a contributer of the Silliman Scientific Journal, published at New Haven, Conn., writes:

"We have received from the American Publishing Company, Middlebury, Vt., a copy of Volume I., second edition, of 'Ellen or Whisperings of an Old Pine.'

"The book is well printed, handsomely bound, and illustrated with many views, presenting both individual subjects and a panorama of large extent and great historic interest, as seen from one of the highest summits of the Green Mountain range in Vermont.

"The work itself, in its entirety, relates to man and his surroundings in the several aspects of his existence, and to the phenomena in the physical world. In treating of these subjects no work in its conception so radical and original has come to the knowledge of the public for many years, nor one that will engage the attention of the thoughtful for so long a period of time. If the attainment of the true reason of things is philosophy, to that extent the work before us may justly be termed the Battellian Philosophy, being an independent consideration of the true knowledge of things by direct investigation, which, while it is carried on Platonically in free conversations or dialogues, is pursued with a Socratic simplicity and certainty that would do credit to the great Athenian—the Master mind of the ages.

"It is also a credit to the work that some of the deductions of the Author in respect to the transmission of light, heat, etc., which were antagonistic to the doctrines taught in the schools, have been by entirely independent investigation and discovery fully verified by eminent scientists both in Europe and America; which suggests that in the future the other tenets of the Author's philosophy will be equally verified.

"A strong moral tone pervades the whole discussion.

"The work also contains an independent investigation of the fixed sciences, commencing with the doctrine of numbers, and embracing the higher mathematics. The purpose of the author in this department of his research manifestly is to criticise and simplify methods that have come down to us unimproved through the dark ages. It certainly will repay teachers and mathematicians to examine this branch of the work, as much light is thrown upon many obscure parts of the subjects as hitherto taught, and these sciences relieved of many unnecessary perplexities and incongruities."

"WHISPERINGS OF AN OLD PINE"

A MASKED ARRAIGNMENT OF MODERN SCIENCE, WITH INSTRUCTIVE READINGS.

From The Springfield (Mass.) Republican, May 17, 1908.

"ELLEN, or Whisperings of an Old Pine," is not a challenge to the usual critics of Nature-faking, despite its peculiar title. It is an elaborate indictment of modern science, and the author has chosen to embody his revolutionary doctrines in the unconventional form of a series of conversations between an old pine-tree and a young woman of remarkable acquirements. The old pine proves to be no crusted conservative, for he listens with approval and interposes only a few leading questions while Ellen tears to pieces the whole fabric of accepted physical theory.

Of course the book is hopelessly astray in its fundamental conceptions; but it is so unlike most of the other works with which it must be classed that it seems a pity to relegate it to such companionship. It is by no means an ignorant production, nor is it without a certain value to the reader equipped with sufficient knowledge to escape being misled. The author sets forth in the fairest possible way the theories he proposes to demolish; that is, he quotes literally and at length from standard scientific writings. These extracts form a very interesting collection, many being from sources difficult of access. There are interesting paragraphs from Papillon, Ivory, Waterston and others, as well as from such writers as Kelvin, Tyndall, and our good old stand-by, Ganot.

Ellen's chief quarrel seems to be with the wave theory of sound and light; but even of Euclidean geometry she admits but shriveled fragments to her philosophy. Synthetic geometry has often been criticised before on the ground that it wastes effort in proving the obvious; and many proposals have been made to replace it by analytical or Cartesian methods in the school curriculum. But Ellen herself furnishes an unconscious argument for holding fast to Euclid. She takes the proposition: "In the same circle or equal circles equal angles at the center intercept equal arcs on the circumference; and conversely." Her demonstration is: "Because the divergence of an angle is uniform," and she takes great credit because she has used 11 words instead of the 70 or more of the usual proof! Of course she might just as well have reduced it to six and said. "Because of the nature of angles." Later, indeed, she does use the phrase "because of the nature of the circle" as an integral member of one of her demonstrations. In these cases the trouble is of course that a hinted explanation is mistaken for proof; and it is just such blunders that an intelligent teaching of Euclid ought to prevent.

Trigonometry and logarithms are not subjected to any vertiginous alterations, though clipped and shrunken greatly by Ellen's avowed disapproval of analytic methods, which she characterizes as "manipulation of symbols." How many students will join in her dislike to such manipulation, which makes a large part of mathematical physics seem like "the way of a serpent upon a rock."

Once at least in each generation some observant person looks about him and perceives that the earth is not spherical, but on the whole visibly and obviously flat. Shall he accept the mere theories of the scientists as against the testimony of his own eyes and against his common sense? On the contrary, he writes a book exposing the absurdity of the theorists' position—and generally secures a considerable following among "practical" people. This is quite comprehensible; but it is not so easy to follow the Ohio astronomer who abandoned the spherical earth for one of toroidal form—changed the orange into a doughnut.

Now the sincere physicist cannot but find a parallel difficulty with Ellen's theories of sound and light. Indeed they are much harder to swallow than a mere doughnut. She not only returns to Newton's theory that light consists of infinitesimal particles of matter projected at high velocity by the source of illumination, but adopts a parallel explanation of sound. It is interesting to recall that the crucial experiment which established the wave-theory of light among physicists was the determination of light-velocity in air and in water, which flatly contradicted the law of refraction deduced from the emission theory by Newton himself. Perhaps even Ellen's skepticism regarding the existence of sound waves in the air might give way before the beautiful photographs of such waves taken by Prof. Wood and others.

Ellen's emission theories are no more likely to shake modern physics than her geometry to supplant Euclid's; but her conversations make an interesting treatise and an extensive one—977 pages octavo. The book is well printed and contains, in addition to scientific diagrams many half-tone pictures of Vermont scenery,—Ellen or Whisperings of an Old Pine.—By Joseph Battell.—American Publishing Company, Middlebury, Vt.: Arthur F. Bird, London,—1908.

To the Editor of The Springfield Republican:—

Permit me to answer the only two adverse criticisms in the quite handsomely written review of "Ellen, or Whisperings of an Old Pine," Volume II., which appeared in your journal of May 17.

First, in mathematics, that a principle "because of the uniform divergence of the sides of an angle," is used in further demonstration which has not itself been fully demonstrated.

The demonstration of this principle is complete in "Ellen," as follows:

"And what does Ellen mean by the uniform divergence of the sides of an angle?"

"Because the sides of a plane angle are straight," she replied, "and have two directions, their divergence must be uniform for whatever distance they extend, and theoretically they extend to infinity. It follows that if their ends are connected at any point by a straight line the length of that line will be just double that connecting the sides at one-half the distance from the apex; or four times as much as that connecting them at one-quarter that distance; and this ratio must hold at all distances.

"This is a very important self-evident principle in mathematics, and may be used to great advantage in the demonstration of many propositions."*

This divergence is uniform in the nature of things, because the lines are straight.

Thus let two straight lines, which are closed, be opened so as to form an angle, this angle will begin with the smallest possible and increase with constant additions of this smallest possible angle, through all intermediate distances, to whatever size the varying angle may extend.

The other criticism relates to the principle of sound, as follows: "Of course the book is hopelessly astray in its fundamental conceptions." This is at best an opinion. If the reviewer will prove that it is so astray we will give him cash, $500.

Mr. Ganot, author of Ganot's Physics, and universally recognized as one of the ablest of modern physicists, takes a very different view of "fundamental conceptions." He says (Chapter I., page 1, of his Physics):

"In our attempts to ascend from a phenomenon to its cause, we assume the existence of physical agents, or natural forces acting upon matter; as examples of such we have gravitation, heat, light, magnetism and electricity. Since these physical agents are disclosed to us only by their effects, their intimate nature is *completely unknown.* In the present state of science, we cannot say whether they are properties inherent in matter [corpuscular], or whether they result from movements impressed in the mass of subtile and imponderable forms of matter diffused through the universe [undulatory]."

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* See "Ellen," Vol. II., page 23.

I notice suggestions by your reviewer of photographs of sound waves taken by Prof. Wood and others. We have seen several similar claims made, but in every case in examining we have found that the thing photographed was disturbance made by electricity. This is fully discussed in "Ellen," Volume II., Part II., pages 337, 338.

If your reviewer will refer us to any reliable account of the photographs he mentions we shall be pleased to consider them. We presume it is another instance of disturbances of conditions caused by electricity being photographed, but such conditions, although they might cause sound, are not sound, any more than the effects of a freshet are sound. The lightning may be photographed, or the effect of it, but we doubt very much whether thunder which represents the sound produced by lightning, can be. Possibly ordinary sound, which as we understand, consists of infinitesimal particles of matter circulating in the atmosphere and other bodies, may yet, through improved methods of photography, be photographed; and this we have mentioned in the pages referred to in "Ellen," but we do not understand that this has yet been accomplished. JOSEPH BATTELL.

—*Middlebury, Vt., June 3, 1908.*

PUBLISHED BY

AMERICAN PUBLISHING COMPANY

MIDDLEBURY, VERMONT.

The Morgan Horse and Register, Vols. I. and II.

By Joseph Battell. Eleven hundred and seven hundred pages respectively. Bound in three fourths leather and handsomely illustrated. Price of Vol I. $5.00, Vol. II. $3.35, or $8.00 for both Volumes, postage prepaid.

THE MORGAN HORSE AND REGISTER, VOL. III., is well under way. It will consist largely of registered horses of both sexes.

OPINIONS OF THE PRESS.

VOL. I. of Battell's Morgan Horse and Register has at last been issued. It is a volume of more than a thousand pages, and no more beautiful press work has ever been seen. The volume shows a vast amount of research aud personal investigation. It contains a great deal which has never before been published, and will probably lead to endless discussion. * * * The portraits of Denning Allen, the Fearnaughts, Lord Clinton and others are gems of art and beauty.

But pictures do not make books, and Mr. Battell's Register is one of the most valuable of recent acquisitions to equine literature, one that should be in the library of every horseman and every student of the breeding problem. No one before has attempted a work of such magnitude, nor has endeavored to get at the evidence on which is based the many beliefs as to the ancestry of many famous ones, and while it may surprise some to find in the first volume the claim that Seely's American Star and old Pacing Pilot are direct descendants of Justin Morgan, it must be admitted the evidence given is quite as conclusive as that upon which is based the claim that their ancestry is in other lines.—[Clark's Horse Review.

The Morgan Horse and Register is the latest and one of the most valuable contributions to horse literature that we have had the pleasure of examining. * * *

It has generally been conceded by those who have studied the subject carefully that the family of horses founded by Justin Morgan has never been equalled as roadsters and for general purposes where animals of heavy weight were not required. * * *

The most surprising pedigree in the work is that of Seely's American Star. It has long been claimed by those who have investigated the matter carefully that he could not have been by Stockholm's American Star, which appeared as his sire in the earlier volumes of Wallace's Trotting Register. Probably Mr. Battell spent more time and money carefully investigating this pedigree and collecting facts in regard to it, than any other in the work, and he has been amply rewarded. After giving the facts fully upon which he bases the pedigree, Mr. Battell gives the breeding of this renowned brood-mare sire as follows:

AMERICAN STAR (SEELY'S).

Chestnut or sorrel, with star, hind feet white, 15½ hands, 1050 pounds; foaled 1837; bred by Henry H. Berry, Pompton Plains, N. J.; got by Coburn's American Star, son of Cock of the Rock, by Sherman Morgan: dam bay, stripe in face, about 16 hands, a used-up stage mare purchased in New York city by Mr. Berry at a small price to work in team, breeding entirely unknown.

The chapters on Justin Morgan and Seely's American Star are alone worth twice the cost of the book. There is also a very interesting chapter on Pilot, sire of Pilot Jr. Mr. Battell traced this horse through all the hands he passed until he located him in Montreal, and there is little doubt that he traced him from that point to his breeder. We are glad to learn from the author that the work is selling rapidly.—[American Horse Breeder.

LEXINGTON, MASS.

JOSEPH BATTELL, ESQ.,

My Dear Sir:—Your valued favor is received; also Vol. I. of the Morgan Horse and Register. As the book was received this morning, I have had little time to read it. It is very handsome and I was particularly pleased with the chapters on the Stars, Pilot, the pacers and the breeding of the original Morgan. I do not see but your claim is admirably sustained.

Very truly yours, EDWARD S. PAYSON.

No publication upon the horse of recent years has awakened so great a public interest as this volume bearing the authorship of Mr. Battell of Vermont.—[Mirror and Farmer, Manchester, N. H.

We have received from Mr. Joseph Battell of Middlebury, Vt., the first Volume of his new work, The Morgan Horse and Register. It is, mechanically, a very fine job: fine paper, elegant binding and illustrations many of them half-tones from photographs, and on fine plate paper, all go to make it an ornament, in the book line, fit for the parlor table. It contains 1000 pages. Whatever adds to the sum of human knowledge in any special line is invaluable and to the specialist indispensable, and Mr. Battell's book should contain within its covers very much that is not only new but important. * * * Probably no man living, in a whole lifetime, ever traveled the distance in pursuit of information, wrote the letters, or spent the hours in historical research that the author of this work has done in the last ten years, and the result is embodied in this volume. * * * Truly "Truth lies at the bottom of the well, and Mr. Battell has gone deeper after it, stayed under longer, and come to the surface with more facts in his grasp than any other writer on the subject. It is a great work, and we have had no time as yet to master its contents, but as time occurs shall refer to it again and again. * * * [J. W. Thompson, author of Maine Bred Horses.

THE HORSEMAN, CHICAGO, ILL.

MR. JOSEPH BATTELL,

My Dear Sir:—The complimentary copy of The Morgan Horse and Register which you are good enough to send me came safely to hand. It is by long odds the most complete and comprehensive work of the kind ever issued, and all the friends and breeders of the Morgan horse owe you a life-long debt of gratitude for your painstaking labor in the field of your choice. It is not only of special value to Morgan horse breeders, but to all others engaged in the light harness horse industry. The illustrations serve a very good purpose and the makeup of the book renders it an ornament to any library. I will give it careful public review at the first chance. Meantime, with best wishes, I am

Yours sincerely, E. C. WALKER. "Veritas."

AMERICAN STALLION REGISTER

IN SIX VOLUMES

BY JOSEPH BATTELL.

"WE have received Volume I. of the above work compiled and published by Joseph Battell of Middlebury, Vt. Mr. Battell has probably spent more time and more of his own money, and has traveled a greater number of miles in search of information relating to the origin and breeding of the light-harness horses of America, than all the other authors who have ever written upon this subject. He is an ardent admirer of the Morgan family of horses, and the author of the very interesting standard work, 'The Morgan Horse and Register.'

"Volume I. of the American Stallion Register is a well-bound book that contains 890 pages of matter relating to pedigrees, etc., exclusive of more than 200 pages of interesting historical and miscellaneous introductory matter, and also contains many fine illustrations mostly of noted horses. The names of the stallions whose pedigrees are given are arranged in alphabetical order. This volume contains all stallions with names beginning with A, B and C. From a hasty examination of the work we believe it to be both interesting and valuable to all breeders of light-harness stock and students of the breeding problem. Many of the pedigrees are different than given in Wallace's American Trotting Register, but Mr. Battell gives his authority for the change and publishes many letters concerning the horses, that he has received from parties who had owned or known the animals. Volume II. is nearly ready for the press."—*S. W. Parlin in American Horse Breeder, April 27, 1909.*

[From The Horse Review, Chicago, May 11, 1909].

We are in receipt, from the publishers, the American Publishing Company, of Middlebury, Vt., of Volume I. of the American Stallion Register, a very handsome book of nearly 900 large and elegantly printed pages, which the sub-title describes as including—

> "All stallions prominent in the breeding of the American roadster, trotter and pacer, from the earliest records to 1902. And this includes nearly all imported English thoroughbreds, and their more distinguished get, together with many the English stallions from which they are descended; all sires of 2:30 trotters or 2:25 pacers; also the rating of Morgan blood in all of these stallions so far as known. Compiled from original sources, with many pedigrees, hitherto incorrectly recorded, corrected (in all cases the evidence upon which this is done being given), and many more pedigrees extended."

The author, as these statements will lead those familiar with pedigrees to apprehend, is Mr. Joseph Battell, of Middlebury, Vt., the author of that very valuable work, "The Morgan Horse and Register," which is one of those most indispensable in the Review's library. Mr. Battell is widely known, and has been for a long term of years, one of the most indefatigable tracers of trotting and pacing pedigrees in America. Like the "Morgan Horse and Register," the present work has been published by Mr. Battell at his own expense and is another monument to his devotion and endeavors. Its magnitude can be appreciated best when it is stated that although the portion of the volume devoted to the list of stallions registered extends, with the "Additions and Corrections," to over 800 pages, it covers only the first three letters of the alphabet. From this it may be estimated that at least three more volumes of similar size will be necessary to complete the work; of which we learn that volume II., is now nearing completion.

Light-Harness horse breeders owe Mr. Battell a heavy debt of gratitude for the enormous amount of time and money that he has expended in labors of which they are the chief beneficiaries, and we hope that they are sensible of it. We, in particular, take pleasure in expressing a lively sense of our own gratitude to him. We cannot say that we endorse all the versions of disputed pedigrees that he has accepted as correct and so registered; of many of them we have considerable doubt while others we disagree in entirely. But this does not affect our opinion that in his pages will still be found a mass of facts of great importance that are nowhere else accessible—which alone confers a very high, and in some ways extraordinary, value upon them.

Typographically the "American Stallion Register" is superb, as it is also as a piece of mechanical book-making, offering thereby a great contrast to the official "American Trotting Register," which in these respects, leaves much to be desired. Aside from the registration department, Volume I. contains over 200 pages of miscellaneous and historical articles, reprinted from various publications which the compiler has selected as being of value for preservation in permanent form; while there are profuse illustrations of noted stallions and landscape views of localities notable in breeding annals.

We tender our thanks to Mr. Battell for the volume and our compliments upon its publication, and trust that nothing may prevent the appearance of the succeeding ones in due time.

PRESTON, MINN., May 13, 1909.

HON. JOSEPH BATTELL,

Dear Sir:—Volume I. of the American Stallion Register, to a truth seeker in pedigrees, is as important as Supreme Court decisions to a lawyer. No other record presents the evidence which you have gathered concerning doubtful pedigrees. Other compilers have presented conclusions, merely, with rarely any evidence and that invariably favorable to one side. To submit the whole case and allow the public to judge, whether your conclusions are in accord with the evidence or not, is a course which should have been the rule for others as well as yourself.

The Wallaceian versions of many pedigrees are now found to have been based upon his predjudices, surmises and desires without any tangible evidence to support them. In fact the evidence in some instances presented to him, destroyed the versions he doggedly adhered to.

No horseman's library is complete without your Stallion Register and no student of breeding can hope to know the truth without reference to it.

Yours truly, M. T. GRATTAN.

[From Breeder and Sportsman, San Francisco, Cal.]

MR. JOSEPH BATTELL, author of the Morgan Horse and Register, has sent us Volume I. of his latest publication, the American Stallion Register, printed by the American Publishing Company of Middlebury, Vt. It is a beautifully printed and illustrated book of nearly 1000 pages, the frontispiece being a half-tone reproduction of ex-President Roosevelt mounted on a charger that is leaping a fence. Volume II. of this work is largely in plate and will soon be issued. The work is one that has cost Mr. Battell a vast amount of labor and money, and it will be of great value to all who are interested in horse pedigrees. Volume I. contains the names of horses arranged alphabetically from A. to C. inclusive. The entire work will consist of six volumes and the price is $5 per volume.

The first Volume of "American Stallion Register" has just come to hand. It is a beautiful book, bound in the most substantial and approved manner, and printed in good clear type.

There are 65 illustrations. Many of these are of noted horses, others are of the localities from which these horses come, and are beautifully executed. The Introduction consisting of over 200 pages, opens with a chapter tracing the horses bred in the Province of Quebec during the first half of the nineteenth century, and which entered in a remarkable degree into the breeding of the early American trotters and pacers. It is shown that the foundation of this stock was the original Morgan horse, imported into northern Vermont adjoining the Province of Quebec, in 1792. Several of his sons were taken to Canada and from this stock crossed with other American and Canadian blood came the large numbers of very fast trotters and pacers, which were imported into the middle, western and southern states, especially Maryland, Kentucky, Indiana and Missouri, included among the first of which were, Copperbottom, Pilot, Tom Hal, Davy Crocket, and many others. Following this chapter the Introduction is divided into Historical, Breeding, The Morgan Horse and Miscellaneous, and includes letters from quite a number of the more prominent early turf writers, Hon. J. S. Skinner, author of the Turf Register, 1829–43; Sanford Howard editor of American Cultivator; John H. Wallace, founder of the American Trotting Register; James D. Ladd; Cyrus Lukens and the very prominent breeders, Senator Stanford, Lucas Brodhead (manager of the great Woodburn farm owned by R. A. Alexander and later A. J. Alexander), Henry N. Smith, C. J. Hamlin and others. In the Introduction are also two very interesting articles on "The Norfolk Trotter" and "The Modern Type of the Hackney Horse" from the English Hackney Stud Book.

Anyone carefully studying the first two hunderd pages would get a liberal education in horse lore and much that is new to the best posted horsemen in our country. The balance of the book is taken up with the Register proper when the name, date and place of birth, description and breeder when known are given, followed by short history of turf and stud career with the number of their get in the list and number of producing sires and dams. The illustrations of noted horses are very fine and include Justin Morgan, Black Hawk, Ethan Allen, Fearnaught, Alexander's Abdallah, Goldsmith's Maid, Almont, Arion, Flora Temple, Blue Bull, Brown Hal, Cresceus, Columbus and many others.

This volume only covers the three first letters of the alphabet, hence, only horses whose names begin with these letters are inserted. If the succeeding volumes are as interesting and complete as this, the work will when finished, be the most valuable work of the kind published in this country, and should be in every library, private and public, in the land. We understand there are to be six volumes in all and that they will be issued as speedily as possible. The price is five dollars per volume, postage or express prepaid.—*Charles A. Chapman, the well known correspondent of several turf journals, in Middlebury (Vt.) Register, May 7, 1909.*

LAWRENCE, KAN., May 24, 1909.

HON. JOSEPH BATTELL, Middlebury, Vt.

Dear Sir:—I am in receipt of a copy of the 1st Volume of your American Stallion Register, and thank you very much, both for the book and the compliment. From what examination I have been able to give it, the work impresses me as incomparably superior to any that has preceded it in the same line. I have no doubt but that it will prove popular with horse breeders generally, and with horse lovers as well.

Very truly yours, O. E. LEARNARD.

NEW YORK CITY, May 21, 1909.

DEAR MR. BATTELL,

I am in receipt of your new book, and beg to thank you for it. Of course I have not examined it thoroughly, but can see at a glance that it involves a vast amount of work and will prove exceedingly valuable for reference. Wishing you success with it I am with best regards.

Yours truly, HAMILTON BUSBY.

CONNERSVILLE, IND., June 2, 1909.

MR. JOSEPH BATTELL,

Dear Sir:—I received my copy of the American Stallion Register, Vol. I., and I consider I got value received the first evening I studied it.

I had spent $5 worth of time and expense in trying to trace the breeding of the Ben Snatcher horses which stood in Morgan County and in my own home town Plainfield, Hendricks County. Your Book told me just what I wanted to know about the Ben Snatchers.

I also wanted to know about the Copperbottoms, and was very much interested in reading about old Copperbottom. I have shod a great many roan Copperbottoms.

I prize the Stallion Register very much and I want to congratulate you on the wide open manner in which you have treated the information you have received. I do not blame you for being predjudiced in favor of the Morgan Horse, but it is a good thing to show the world your information, rather than your opinions. The book represents a large amount of careful work and I appreciate it. With best wishes I am,

Respectfully, JOHN T. WILKIN.

ORWELL, Vt., June 7, 1909.

HON. JOSEPH BATTELL,

My Dear Sir:—I hope you will not interpret this rather untimely acknowledgment of your very kind favor of Vol. I., of American Stallion Register as an indication that it was not fully appreciated, for it certainly was and it reflects great credit upon your untiring perseverance in compiling it. It should be in every library where there is any interest or love for that most noble of all animals—the Horse. Again thanking you,

I am truly, H. T. CUTTS.

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ILLUSTRATED with 125 very superior half tones, consisting of American and foreign scenery, portraits of distinguished authors, and copies of celebrated paintings. Volume I., consists of 429 pages besides illustrations.

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